JT3D-1, D-1A, D-3, D-3B, D-3C, D-1-MC6, D-1A-MC6, D-1-MC7, AND D-1A-MC7 TURBOFAN

MAINTENANCE MANUAL

PART NO. 411566

MARCH 1/60

REVISED DECEMBER 15/ 88

FAA APPROVED

UNITED TECHNOLOGIES
PRATT & WHITNEY

UNITED TECHNOLOGIES
PRATT&WHITNEY

P.O. Box 611
Aircraft Road
Middletown, Connecticut 06457

Commercial Engine Business

December 15, 1988

Subject: JT3D Maintenance Manual, Part Number 411566, Revision No. 38, dated December 15, 1988

This transmittal package contains the subject revision, including Temporary Revision Highlights. Please file this revision in accordance with each applicable List of Effective Pages contained herein.

To avoid any break in the continuity of revision service, please direct any change in address or revision requirements to my attention.

Sincerely,

Joan C. Olson

Joan C. Olson
Supervisor, Distribution
Technical Publications & Maintenance Data Services
Customer Support

ccb

TO: RECIPIENTS OF THE JT3D TURBOFAN ENGINE MAINTENANCE MANUAL, PART NUMBER 411566.

REVISION NO. 38 DATED DECEMBER 15, 1988

HIGHLIGHTS

Pages which have been revised are outlined below, together with the highlights of the revision. Recipients of PRINTED MANUALS shall refer to the List of Effective Pages for filing instructions.

To avoid any break in the continuity of revision service, please direct any changes in address or revision requirements to: Supervisor, Distribution, Technical Publications & Maintenance Data Services, Customer Support, Pratt & Whitney, P.O. Box 611, Middletown, CT 06457.

Chapter/Section	Page No.	Description Of Change	Effectivity
Title		Revised.	
Introduction		Revised.	
72-0 Engine Dismantling/ Assembly	424Q-424AE/424AF	Added damaged engine and engine parts guidelines.	
72-0 Engine Inspection/Check	660	Increased crack limit for diffuser case.	
79-0 Oil	201	Changed "power" to "N2 speed" in oil scavenging procedure. Remove TR 79-3.	

TO: RECIPIENTS OF THE JT3D TURBOFAN ENGINE MAINTENANCE MANUAL, PART NO. 411566.

REVISION NO. 38 DATED DECEMBER 15, 1988

TEMPORARY REVISION HIGHLIGHTS

INACTIVE

The following Temporary Revisions are now inactive and should be removed from your PRINTED MANUALS and from the file of Temporary Revisions used in conjunction with MICROFILM.

Temp. Rev. No.	Filed Adjacent To	Remarks	Effectivity
72-141	72-0, Page 424Q	Incorporated	
79-3	79-0, Page 201	Incorporated	

ACTIVE

The following Temporary Revisions and any issued after October 30, 1985 are active and are to be retained in PRINTED MANUALS and in MICROFILM Temporary Revision file until otherwise directed by subsequent filing instructions.

Temp. Rev. No.	Filed Adjacent To	Remarks	Effectivity
None			

JT3D-1, D-1A, D-3, D-3B, D-3C, D-1-MC6, D-1A-MC6, D-1-MC7, AND D-1A-MC7 TURBOFAN

MAINTENANCE MANUAL

PART NO. 411566

MARCH 1/60

REVISED DECEMBER 15/ 88

FAA APPROVED

UNITED TECHNOLOGIES
PRATT & WHITNEY

LIST OF REVISIONS

REV NO	DATE	REV NO	DATE	REV NO	DATE
Basic	Mar 1/60	23	Jan 15/72		
1	Jun 1/60	24	Jul 15/72		
2	Sep 1/60	25	Jan 15/73		
3	Dec 1/60	26	Apr 1/74		
4	Apr 1/61	27	Dec 15/75		
5	May 1/61	28	Jun 15/76		
6	Aug 1/61	29	Dec 15/76		
7	Nov 15/61	30	Jun 15/77		
8	Apr 15/62	31	Dec 15/77		
9	Aug 1/62	32	Jun 15/78		
10	May 15/63	33	Dec 15/78		
11	Jul 1/63	34	Jan 1/80		
12	Sep 15/63	35	Jul 1/80		
13	Dec 15/63	36	Jul 1/85		
14	Feb 1/64	37	Dec 15/86		
15	Jun 1/65	38	Dec 15/88		
16	Dec 1/66				
17	Dec 1/67				
18	May 15/68				
19	Dec 1/568				
20	Aug 1/69				
21	Apr 15/70				
22	Jul 15/71				

LIST OF EFFECTIVE PAGES

Please insert the revised pages into this manual and delete obsolete pages in accordance with the following List of Effective Pages. Revised pages are indicated by the letter "R", added pages by the letter "A", and deleted pages by the letter "D". Superseded pages shall be removed and destroyed.

The List of Effective Pages records not only each page of subject revision but also each previously issued page which is still current. Blank pages and pages which are no longer current do not appear on this list. If there is any question about the currency of the recipient's copy, it is recommended that each page of the manual be checked off against this List of Effective Pages. Any page which does not check out with this list, either by number or by date, shall be discarded.

CHAPTER/ SECTION		PAGE	DATE
	R/	Title (Vol. 1)	Dec 15/88
List of Revisions			
List of Effective Pages - Introduction			
	R/	A/B	Dec 15/88
List of Service Bulletins			
		Bul-1/ Bul-2	Jul 1/80
Introduction			
		i	Jul 1/85
		ii	Jul 1/85
		iii	Jul 1/85
		iv	Jul 1/85
		v	Mar 1/60

List of Incorporated Service Bulletins

The intent of each Service Bulletin identified below which is of a repetitive nature has been incorporated in this manual. ONE TIME changes are assumed to be accomplished in accordance with the applicable bulletin instructions and are consequently not considered of maintenance manual significance.

327
392
458
548
549
573
609
765
794
1771
1809
2016 R13
2150
4453
4453 R3
4453 R5
4882
5077
5083

INTRODUCTION

This publication is complied and issued by the Product Support Department of Pratt & Whitney, Division of United Technologies Corporation, East Hartford, Connecticut 06108. This manual, as it may be supplemented by P&W service bulletins, constitutes authoritative statement of Pratt & Whitney approved and recommended maintenance procedures for JT3D series engines. The information and instructions contained herin are based upon actual experience acquired under varied and exacting conditions. The utmost in dependable engine performance will be gained by conforming to these instructions.

Unusual problems concerning engine maintenance should be presented to the Product Support Department either through its field representatives or by direct contact. All possible assistance will be provided toward solution of these problems.

Requests for pertinent information not covered by this publication, and suggestions for modification or amplification of these instructions so as to increase their usefulness, will be welcomed by Pratt & Whitney Product Support Department.

This publication will be revised as necessary to incorporate latest approved data.

SUPPLEMENTARY PUBLICATIONS

It is recommended that personnel concerned with engine maintenance also familarize themselves with following publications:

Overhaul Manuals - The Part No. 411568 Overhaul Manual contains the instructions required for the major overhaul of the basic engines (less accessory components) covered in this manual. Light Overhaul Procedures are also included in Part No. 411568. The Part No. 411569 Overhaul Manual contains the instructions required for the major overhaul of the accessory components. Part No. 585005 Standard Practices Manual contains approved and recommended standard practices information, instructions, and procedures used repeatedly on various engines manufactured by Pratt & Whitney.

Illustrated Parts Catalog - The Part No. 411570 (JT3D-1, JT3D-3, and JT3D-3B) Part No. 424829 (JT3D-1-MC6), and Part No. 443089 (JT3D-1-MC7) Illustrated Parts Catalog list and illustrate all salable parts of the engines covered in this manual.

Service Bulletins - Service Bulletins will be issued as required to provide information or instructions for modifying earlier production engines or parts to the latest configuration.

PARTS AND SERVICE

Product Support Department - Pratt & Whitney maintains a Product Support Department to assist its customers in the operation, maintenance, and overhaul of Pratt & Whitney engines. Product Support Department representatives maintain contact with operators and engine service activities and are available for the investigation of any specific difficulty or problem. Any request for assistance should be addressed directly to the Product Support Department, Pratt & Whitney, East Hartford, Connecticut.

Ordering Parts

Whenever possible, refer to the appropriate Illustrated Parts Catalog, when ordering parts. In case a parts list is not available, give engine model, manufacturer's engine serial number, and a full description of the part and where it is used. All spare parts orders should be addressed directly to the Spare Parts Department, Pratt & Whitney, East Hartford, Connecticut.

Because some parts require special or expensive equipment for assembling and cannot be fabricated except in a specially equipped shop, they are not furnished individually and must be purchased as assemblies. If an order is received for a unit of an assembly coming under this classification, the complete assembly will be shipped.

Returning Parts

All material being returned for investigation is to be shipped to the following address:

USA Based Operators	Non-USA Based Operators
PRATT & WHITNEY Product Support Department 400 Main Street Receiving Well #3 East Hartford, Connecticut 06108	UNITED TECHNOLOGIES INTERNATIONAL c/o PRATT & WHITNEY Product Support Department 400 Main Street Receiving Well #3 East Hartford, Connecticut 06108 USA

Material returned is to be accompanied by a number five (5) Request for Support Allowance (RSA) copy.

Parts must be packaged adequately to prevent damage in transit. Parts removed from various engines or having different part times should be individually tagged and covered by separate RSA's.

Material eligible for Service Policy Benefits and returned to the Pratt & Whitney Service Center is to be shipped to the following address:

USA Based Operators	Non-USA Based Operators
PRATT & WHITNEY Product Support Department Service Center Southington, Connecticut 06489	UNITED TECHNOLOGIES INTERNATIONAL c/o PRATT & WHITNEY Product Support Department Service Center Southington, Connecticut 06489 USA

Material returned is to be accompanied by a number five (5) copy of an RSA. Material so returned should be covered by the operator's charge purchase order to facilitate proper billing.

Numbering System

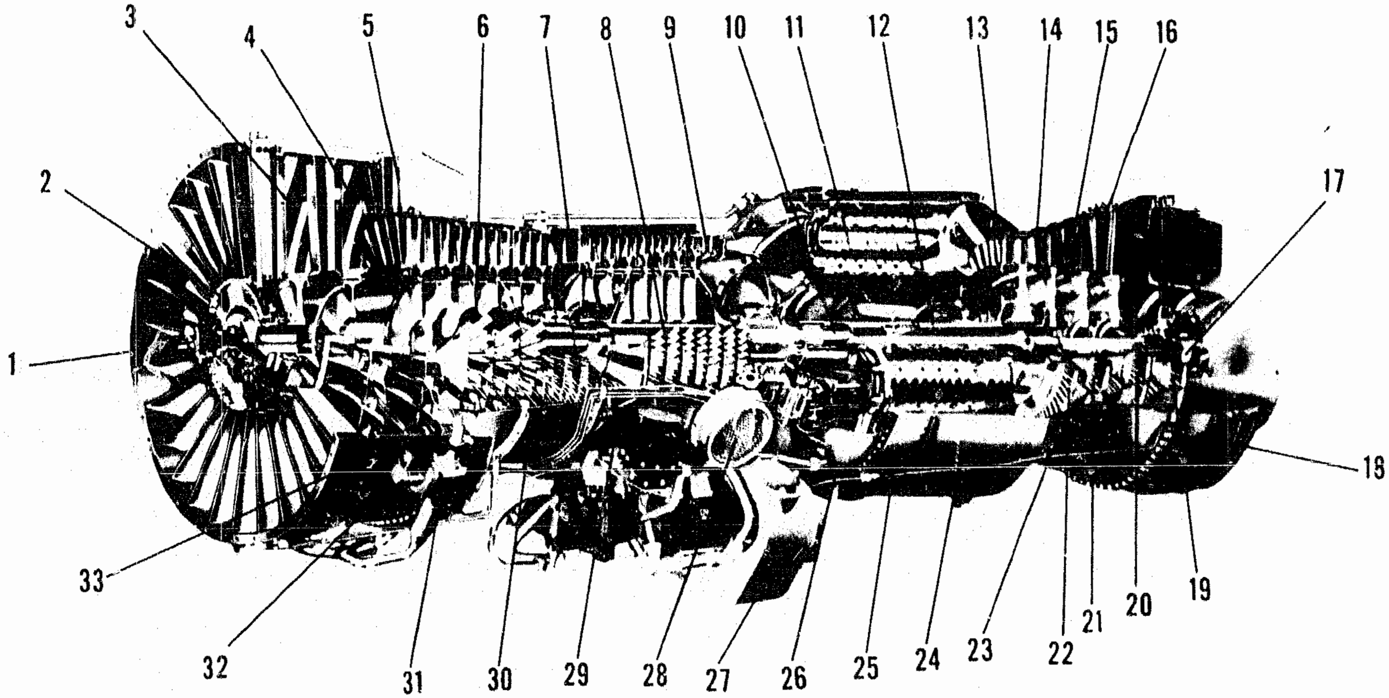
A three-element code number appears at the lower outside corner of each page. The first number is the chapter number, identifying and locating the instructions within the airframe manual. The second number designates the section breakdown in the chapter. The third number designates the subject. How the second and third dash numbers have been assigned to the various assemblies and subassemblies of the engine will be readily apparent from a consideration of the Table of Contents.

Chapter Responsibilities

In cooperation with engine and accessory manufacturers, Pratt & Whitney furnishes, or contributes to, the following chapters:

Chapter	Title	Maint.	Overhaul	Illustrated Parts Cat.
*70	Standard Practices Engine		X	
*72	Engine	X	X	X
73	Engine Fuel and Control	X	X	X
74	Ignition	X	X	X
75	Air	X	X	X
77	Engine Indicating	X	X	X
79	Oil	X	X	X
82	Water Injection	X	X	X

*Sole responsibility of P&W



1. COMPRESSOR BLEED CONTROL
2. FRONT ACCESSORY SUPPORT
3. FIRST STAGE BLADES (FAN)
4. SECOND STAGE BLADES (FAN)
5. FRONT COMPRESSOR EXIT VANES
6. FRONT COMPRESSOR ROTOR
7. COMPRESSOR INTERMEDIATE INLET VANES
8. REAR COMPRESSOR ROTOR
9. COMPRESSOR EXIT GUIDE VANES
10. FRONT COMPRESSOR DRIVE TURBINE ROTOR SHAFT
11. COMBUSTION CHAMBER
12. REAR COMPRESSOR DRIVE TURBINE ROTOR SHAFT
13. FIRST STAGE TURBINE VANES
14. SECOND STAGE TURBINE VANES
15. THIRD STAGE TURBINE VANES
16. FOURTH STAGE TURBINE VANES
17. NO. 6 BEARING SUMP AREA
18. TURBINE EXHAUST CASE
19. FOURTH STAGE TURBINE DISK & BLADES
20. THIRD STAGE TURBINE DISK & BLADES
21. SECOND STAGE TURBINE DISK & BLADES
22. FIRST STAGE TURBINE DISK & BLADES
23. TURBINE NOZZLE CASE
24. COMBUSTION CHAMBER REAR OUTER CASE
25. COMBUSTION CHAMBER FRONT OUTER CASE
26. DIFFUSER CASE
27. ACCESSORY COMPONENTS GEAR BOX
28. COMPRESSOR BLEED VALVE
29. COMPRESSOR INTERMEDIATE CASE
30. FRONT COMPRESSOR REAR CASE
31. ANTI-ICING AIR VALVE & ACTUATOR
32. FRONT COMPRESSOR FRONT CASE
33. COMPRESSOR INLET CASE

Cut-a-way View of a Typical Turbofan Engine
Figure i

LIST OF EFFECTIVE PAGES

Please insert the revised pages into this manual and delete obsolete pages in accordance with the following List of Effective Pages. Revised pages are indicated by the letter "R", added pages by the letter "A", and deleted pages by the letter "D". Superseded pages shall be removed and destroyed.

The List of Effective Pages records not only each page of subject revision but also each previously issued page which is still current. Blank pages and pages which are no longer current do not appear on this list. If there is any question about the currency of the recipient's copy, it is recommended that each page of the manual be checked off against this List of Effective Pages. Any page which does not check out with this list, either by number or by date, shall be discarded.

LIST OF EFFECTIVE PAGES

CHAPTER/ SECTION		PAGE	DATE
72-0		418F	Dec 15/76
		418G/418H	Dec 15/76
		418J/418K	Dec 15/77
		418L/418M	Jun 15/77
		418N/418P	Jun 15/76
		418Q/418R	Jun 15/76
		419/420	Jun 15/76
		420A/420B	Jun 15/76
		420C/420D	Jun 15/76
		420E/420F	Jun 15/76
		420G/420H	Jun 15/76
		420J/420K	Jun 15/76
		420L	Jun 15/76
		420M	Jun 15/76
		420N	Jun 15/76
		420P	Jun 15/76
		420Q/420R	Jun 15/76
		421/422	Jun 15/76
		422A/422B	Jun 15/76
		422C/422D	Jun 15/76
		422E	Jul 1/85
		422F	Jun 15/76
		422G/422H	Jun 15/76
		422J/422K	Jun 15/76
		422L/422M	Jun 15/76
		422N/422P	Jun 15/76
		423/424	Jun 15/76
		424A/424B	Jun 15/76
		424C	Jul 1/85
		424D	Jun 15/76
		424E	Jun 15/76
		424F	Jun 15/76
		424G	Jun 15/76
		424H	Jun 15/76
		424J	Jun 15/77
		424K	Jun 15/76
		424L	Jun 15/76
		424M	Jun 15/76
		424N	Jun 15/77
		424P	Jun 15/76
	R/	424Q	Dec 15/88
	R/	424R	Dec 15/88
	R/	424S	Dec 15/88
	R/	424T	Dec 15/88
	R/	424U	Dec 15/88
	R/	424V	Dec 15/88
	R/	424W	Dec 15/88
	A/	424X	Dec 15/88
	A/	424Y	Dec 15/88
	A/	424Z	Dec 15/88
	A/	424AA	Dec 15/88
	A/	424AB	Dec 15/88
	A/	424AC	Dec 15/88
	A/	424AD	Dec 15/88
	A/	424AE/424AF	Dec 15/88
		425	Jun 1/65
		426	Dec 15/63
		427	Dec 15/63
		428	Dec 15/76
		429	Dec 1/67
		430	Dec 1/67
		431	Dec 1/67
		432	Dec 15/75
		433	May 15/68
		434	May 15/68
		434A	Apr 1/74
		434B	Apr 1/74
		434C	Apr 1/74
		434D	Apr 1/74
		434E	Apr 1/74
		434F	Dec 15/76
		434F-1/ 434F-2	Jan 1/80
		434G	Jan 1/80

CHAPTER/ SECTION	PAGE	DATE
72-0	434H	Apr 1/74
	434J	Apr 1/74
	434K	Apr 1/74
	434K-1/ 434K-2	Jul 1/80
	434L	Jul 1/80
	434M	Apr 1/74
	434N	Apr 1/74
	434P	Dec 15/76
	434Q	Apr 1/74
	434R	Dec 15/76
	434S	Apr 1/74
	434T	Apr 1/74
	434U/434V	Apr 1/74
	435	Apr 1/74
	436	Apr 15/70
	437	Apr 15/70
	438	Dec 15/78
	439	Jun 15/78
	440	Apr 15/70
	441	Jun 15/78
	442	Jun 15/78
	442A/442B	Jun 15/78
	443	Jan 1/80
	444	Apr 15/70
	445	Apr 15/70
	446	Apr 15/70
	447	Dec 15/75
	448	Jun 15/77
	449	Dec 15/75
	450	Apr 15/70
	451	Jul 1/85
	452	Apr 15/70
	453	Apr 15/70
	454	Apr 1/74
	455	Dec 15/76
	456	Dec 15/76
	501	Dec 1/67
	502	May 15/68
	502A	May 15/68
	503	Apr 15/62
	504	Apr 15/62
	505	Aug 1/69
	506	Dec 15/77
	506A	Aug 1/69
	506B	Jul 1/85
	507	Jul 1/85
	508	Jun 15/78
	509	Dec 15/77
	510	Jul 1/85
	511/512	Dec 15/77
	513/514	Dec 15/77
	514A/514B	Jul 1/85
	515/516	Dec 15/77
	516A/516B	Jul 1/85
	517/518	Jun 15/78
	519/520	Jun 15/78
	521	Jul 1/85
	522	Jul 15/72
	523	Jul 15/72
	524	Jul 15/72
	525	Jul 15/72
	526	Jul 15/72
	527	Jul 15/72
	528	Jul 15/72
	529/530	Dec 15/75
	531/532	Jul 15/72
	533	Jul 15/72
	534	Jul 15/72
	535	Dec 15/75
	536	Jul 15/72
	537	Jul 15/72
	538	Jan 1/80
	539	Jul 15/72

CHAPTER/ SECTION	PAGE	DATE
72-0	540	Jan 1/80
	541	Jan 1/80
	542	Jan 1/80
	543/544	Jul 15/72
	544A/544B	Jun 15/78
	545/546	Jul 15/72
	546A/546B	Jun 15/78
	547/548	Jul 15/72
	548A/548B	Jun 15/78
	549/550	Dec 15/75
	601	Jul 1/85
	602	Jul 15/71
	603	Jul 15/71
	604	Jul 15/71
	605	Jul 15/71
	606	Jul 15/71
	607	Jul 15/71
	608	Jul 1/85
	609	Jul 1/85
	610	Jan 15/73
	611	Jul 1/85
	612	Jul 15/71
	613	Jul 15/71
	614	Jul 1/85
	614A/614B	Jul 1/85
	615	Jul 15/71
	616	Jul 1/85
	617	Jul 1/80
	618	Jul 1/85
	619	Jul 1/85
	620	Jul 1/85
	621	Jul 1/85
	622	Jan 15/72
	623	Jan 15/72
	624	Jan 15/73
	624A	Jun 15/76
	624B	Jan 15/73
	624C	Dec 15/77
	624D	Jul 1/85
	624E/624F	Jul 1/85
	625	Jul 1/85
	626	Jul 15/72
	627	Jul 15/72
	628	Jan 15/72
	629	Jan 15/72
	630	Jan 15/72
	631	Jan 15/72
	632	Jan 15/72
	633	Jan 15/72
	634	Jan 15/72
	635	Jan 15/72
	636	Jan 15/72
	637	Jan 15/72
	638	Jan 15/72
	639	Jan 15/72
	640	Jan 15/72
	641	Jan 15/72
	642	Apr 1/74
	643	Jan 15/72
	644	Jan 15/73
	645	Jan 15/72
	646	Jan 15/72
	646A/646B	Dec 15/78
	647	Apr 1/74
	648	Jul 15/72
	649	Jan 15/72
	650	Jan 15/72
	651	Jan 15/72
	652	Apr 1/74
	652A	Apr 1/74
	652B	Apr 1/74
	652C	Apr 1/74
	652D	Apr 1/74
	652E	Apr 1/74

LIST OF EFFECTIVE PAGES

CHAPTER/ SECTION		PAGE	DATE	CHAPTER/ SECTION	PAGE	DATE	CHAPTER/ SECTION	PAGE	DATE
72-0		652F	Apr 1/74						
		652G/652H	Dec 15/75						
		653	Jan 15/72						
		654	Jan 15/72						
		655	Jan 15/72						
		656	Dec 15/86						
		657	Jul 1/80						
		658	Jul 1/80						
		658A/658B	Apr 1/74						
		659	Jun 15/78						
	R/	660	Dec 15/88						
		661	Apr 1/74						
		662	Apr 1/74						
		663	Jul 1/85						
		664	Jan 15/73						
		665	Jul 1/85						
		666	Jan 15/73						
		667/668	Jul 1/85						
		701	Sep 15/63						
		702	Jul 1/85						
		703	May 15/63						
		704	May 15/63						
		705	Aug 1/69						
		706	Jul 1/80						
		707	Jul 1/80						
		708	Jul 1/80						
		709	Jul 1/80						
		710	Jul 1/80						
		801	Jun 15/77						
		802	Jun 15/77						
		802A	Jul 1/80						
		802B	Jun 15/77						
		803	Jul 15/71						
		804	Jul 1/80						
		805	Jul 1/80						
		806	Jul 1/85						
		806A/806B	Jul 1/80						
		807	Jan 15/72						
		808	Jan 15/72						
		809	Jan 15/72						
		810	Apr 1/74						
		811	Apr 1/74						
		812	Dec 15/75						
		813	Apr 1/74						
		814	Dec 15/78						
		815	Dec 15/76						
		816	Dec 15/78						
		817	Dec 15/78						
		818	Dec 15/86						
		819	Dec 15/78						
		820	Dec 15/86						
		821	Dec 15/86						
		822	Dec 15/86						
		823/824	Dec 15/86						

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ENGINE - DESCRIPTION AND OPERATION

General

These instructions are based on the assumption that the reader is already familiar with the fundamentals and theory of a turbofan engine. In the description of the JT3D engine, frequent reference may be made to fundamental and theoretical principles as an aid to discussing the relationships of the parts. If the reader is not yet familiar with turbofan fundamentals and theory, it is recommended that reference be made to publications which supply this information.

The engine operates similarly to all turbofan versions of a gas turbine engine. The first two front compressor stages of vanes and blades are considerably larger than the other stages and are commonly referred to as the "fan". This "fan" provides two separate air streams. The primary (or inner) air stream travels through the engine and internal devices operate to generate pressures and gases in the exhaust nozzle and thereby provide the propulsive force. The secondary (or outer) air stream is mechanically compressed by the "fan" as it enters the engine and is ducted to outside the engine a short distance from the "fan". This secondary air stream adds to the propulsive force similar to a propeller. Although the "fan" has the effect of a geared propeller, it is driven at engine speed. The efficiency of the engine is increased by the dual air streams, and since a smaller percent of available energy is diverted to the "fan", the thrust specific fuel consumption is lower than that of a comparable turboprop engine.

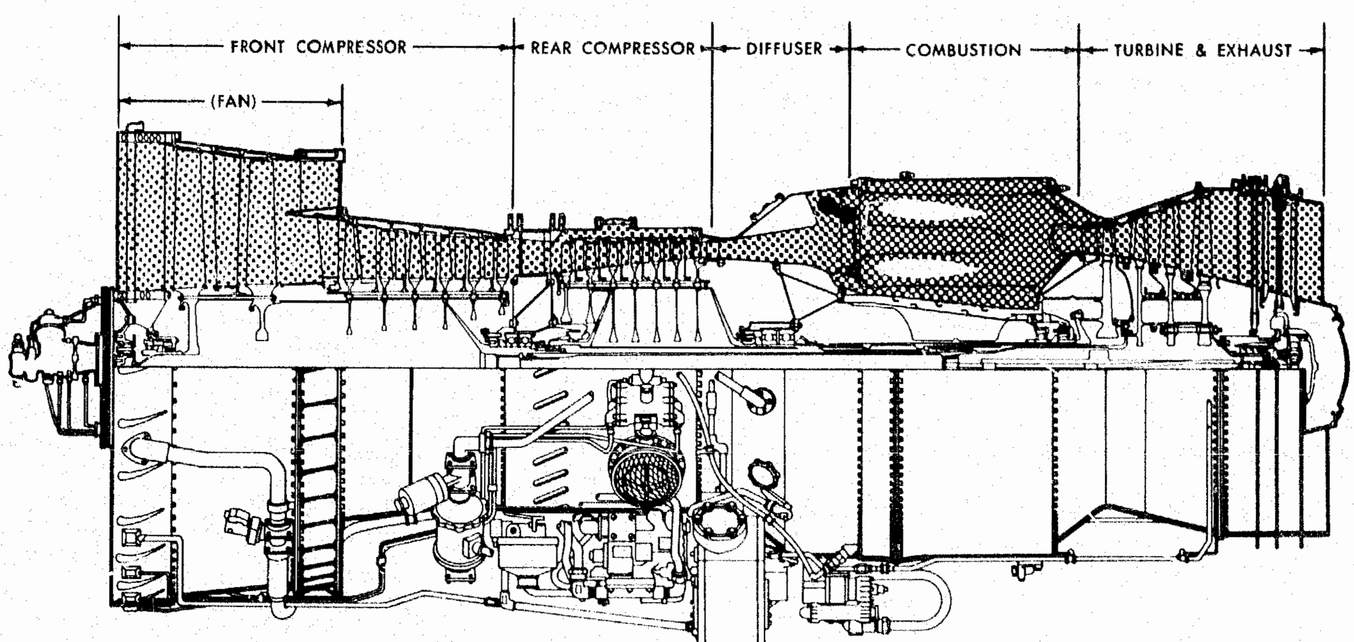
The JT3D is an axial flow turbofan engine having a fifteen stage split compressor, an eight can combustion chamber, and a four stage split turbine. See Figure 1.

Model Differences

This publication covers JT3D-1,-1A (Boeing and Douglas), JT3D-3 (Boeing and Douglas), JT3D-3B,-3C (Boeing, Douglas, and Douglas Long Duct), JT3D-1-MC6,-1A-MC6 (Boeing and QANTAS) and JT3D-1-MC7,-1A-MC7 engines.

The JT3D-3 and JT3D-3B engines are mechanically identical except for minor internal differences. Operationally, the standard day dry TAKE-OFF thrust rating for JT3D-3B has been extended to include ambient temperature up to 80 °F.

The JT3D engine, without airframe installations, is approximately 136 inches long and 53 inches in diameter at the "fan" section. With all engine provided accessory components installed (aircraft component mounting brackets excepted, the JT3D-1,-1A engine weighs approximately 4130 pounds, the JT3D-3 weighs approximately 4170 pounds, the JT3D-3B,-3C approximately 4340 pounds, the JT3D-1-MC6 -1A-MC6 approximately 4540 pounds, and the JT3D-1-MC7,-1A-MC7 approximately 4165 pounds. The aircraft equipment brackets weigh 10 pounds and the fuel de-icing system weighs 45 pounds.



Typical JT3D Turbofan Engine (Gas Flow)
Figure 1

ENGINE - DESCRIPTION AND OPERATION

The JT3D-1A,-1A-MC6, -1A-MC7 and the JT3D-3C Engines are new versions of the JT3D-1,-1-MC6,-1-MC7 and JT3D-3B Engines respectively, and incorporate part changes for smoke reduction. The changes enable the new versions to meet visible smoke limits introduced by the Environmental Protection Agency of the United States Government. These new engines incorporate the following parts which are different from those in their respective non reduced smoke engine models:

Pressurizing and Dump Valve Assembly.
Fuel Manifold Assemblies incorporating new aerating nozzles and new nozzle retaining nuts.
8 Combustion Chamber Assemblies.
8 Combustion Chamber Clamp Assemblies.
8 Combustion Chamber Clamp Assembly Heatshields.
Combustion Chamber Outlet Duct Assembly.

R

All procedures in this manual are applicable to the respective reduced smoke engine models except for those dealing with the peculiar assemblies noted above.

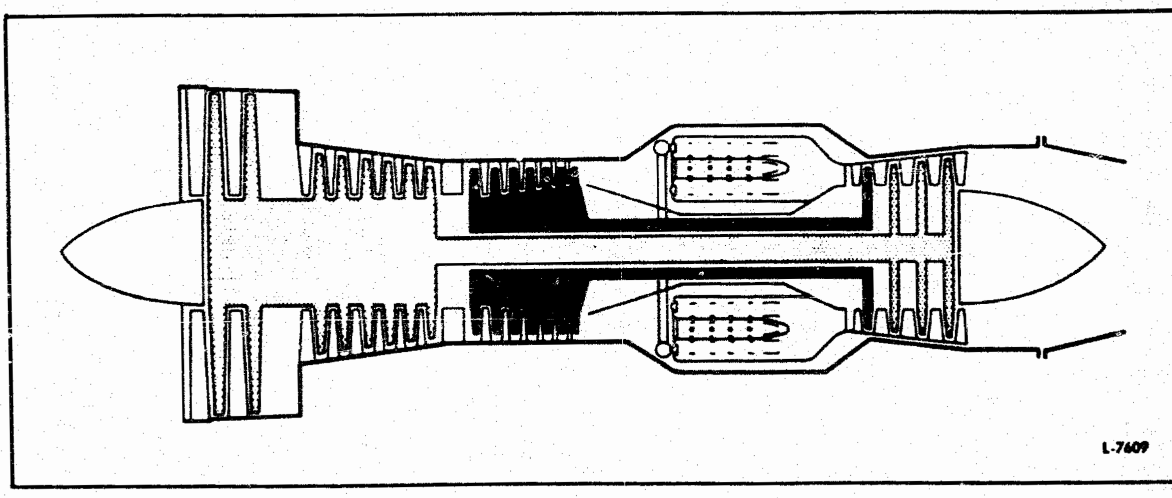
Operation

The outline which follows functionally traces the continuous gas flow through the engine in terms of the parts which direct and activate this gas flow. See Figure 1.

The air enters the engine through the compressor inlet case assembly. The airframe inlet duct is attached to the front of the inlet case. This inlet case assembly is provided with vane-type multi-purpose struts which transmit No. 1 Bearing loads to the outer case structure, conduct anti-icing air, and lubricating oil to the inner diameter of the engine and direct the air to the front compressor section.

The compressor section is of the split-type and consists of two rotor assemblies. Each rotor assembly is driven by an independent turbine, and each rotor is free to rotate at its best speed. See Figure 2. Since it is necessary to rotate only one of these units during the starting operation, the selection of the small (rear compressor) permits the use of a smaller starter.

ENGINE - DESCRIPTION AND OPERATION



Split Compressor and Turbine Arrangement

Figure 2

Air from the inlet guide vane and shroud assembly enters the front compressor, which consists of eight rotor stages and seven vane stages. The gas path of this compressor has a constant inside diameter and a decreasing outside diameter. This compressor is the larger of the two, and provides the initial compression of air. The rotating parts are connected by a drive shaft which passes through the inside of the rear compressor rotor and drive shaft to the second third and fourth stage turbines.

Between the front and rear compressor is the intermediate case. It has an automatic arrangement for bleeding front compressor air. This is to improve the acceleration characteristics of the engine. The inlet vanes (9th stage) transmit No. 2 and No. 3 Bearing loads to the outer case, conduct supply and return oil to bearings, and direct the compressed air from the front compressor to the rear compressor.

The rear compressor has seven rotor stages and six vane stages. It has a constant outside diameter and an increasing inside diameter, and is driven by the first stage turbine through an independent shaft concentric with the front compressor drive shaft. Just aft of the rear compressor is the diffuser case.

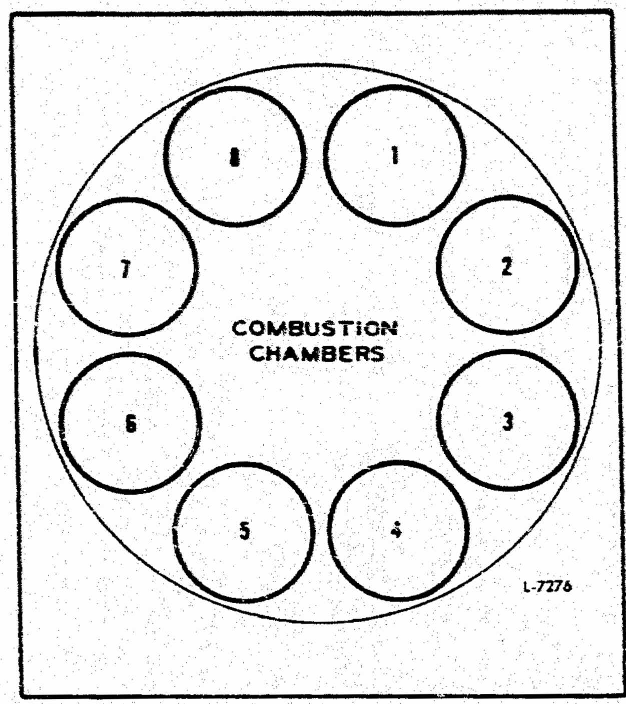
Compressor exit guide vanes at the front of the diffuser case straighten the air which is then expanded for entry into the combustion chambers. Struts in the case transmit the No. 4 Bearing and No. 5 Bearing loads to the outer portion of the case. In addition, these struts conduct bearing oil pressure and suction lines and provide high pressure air for such engine functions as anti-icing.

ENGINE - DESCRIPTION AND OPERATION

They also provide a source of clean air for aircraft pressure needs. The water injection manifold is mounted on the front flange. The coolant is dispersed through sixteen curled tubes mounted on the periphery of the diffuser case, through mating holes in the case and injected into the air stream. The outside contours of the compressor and diffuser sections give the engine its "wasp waist" and at the same time provide a convenient location for the accessory section.

The fuel manifold, which consists of eight circular clusters of six fuel nozzles, is located in the diffuser case annulus and injects the fuel into the air stream in governed proportions. At this point, the air is channeled into eight portions for burning with the fuel in the eight combustion chambers.

The combustion section consists of eight separate cans arranged annularly (hence the name "can-annular" or "cannular burners"). The chambers, as viewed from the rear of the engine, are numbered in a clockwise direction starting with the uppermost chamber as No. 1. See Figure 3. These chambers are connected by cross-over tubes. The compressed air, its velocity decreased, and now with fuel particles injected, is lighted initially by sparkigniters installed in the No. 4 and No. 5 combustion chambers. After "light-up" the flame is perpetuated by the construction of the combustion chamber and the heat generated by previous combustion. The exhaust gases pass through the combustion chamber outlet duct into the turbine nozzle case.



Combustion Chamber Positions

The turbine nozzle case houses the first stages of the four stage turbine and is aft of the combustion section. The first stage drives the rear compressor, and the second, third, and fourth stages drive the front compressor. The turbine nozzle case also contains the four turbine exhaust nozzles. The nozzles are made up of a series of stationary vanes which direct the exhaust gases through the turbine blades and into the turbine exhaust case.

To the rear of the turbine nozzle case is the turbine exhaust case which houses the fourth stage turbine disk and blades and through which the exhaust gases are ejected from the engine. The turbine exhaust case also supports the No. 6 Bearing and the No. 6 Bearing oil sump.

Description

General

Right and left, clockwise and counterclockwise, upper and lower, and similar directional references, apply to the engine as viewed from the rear (exhaust duct) with the main accessory housing at the bottom of the engine. The directional rotation of the rotor assemblies is clockwise.

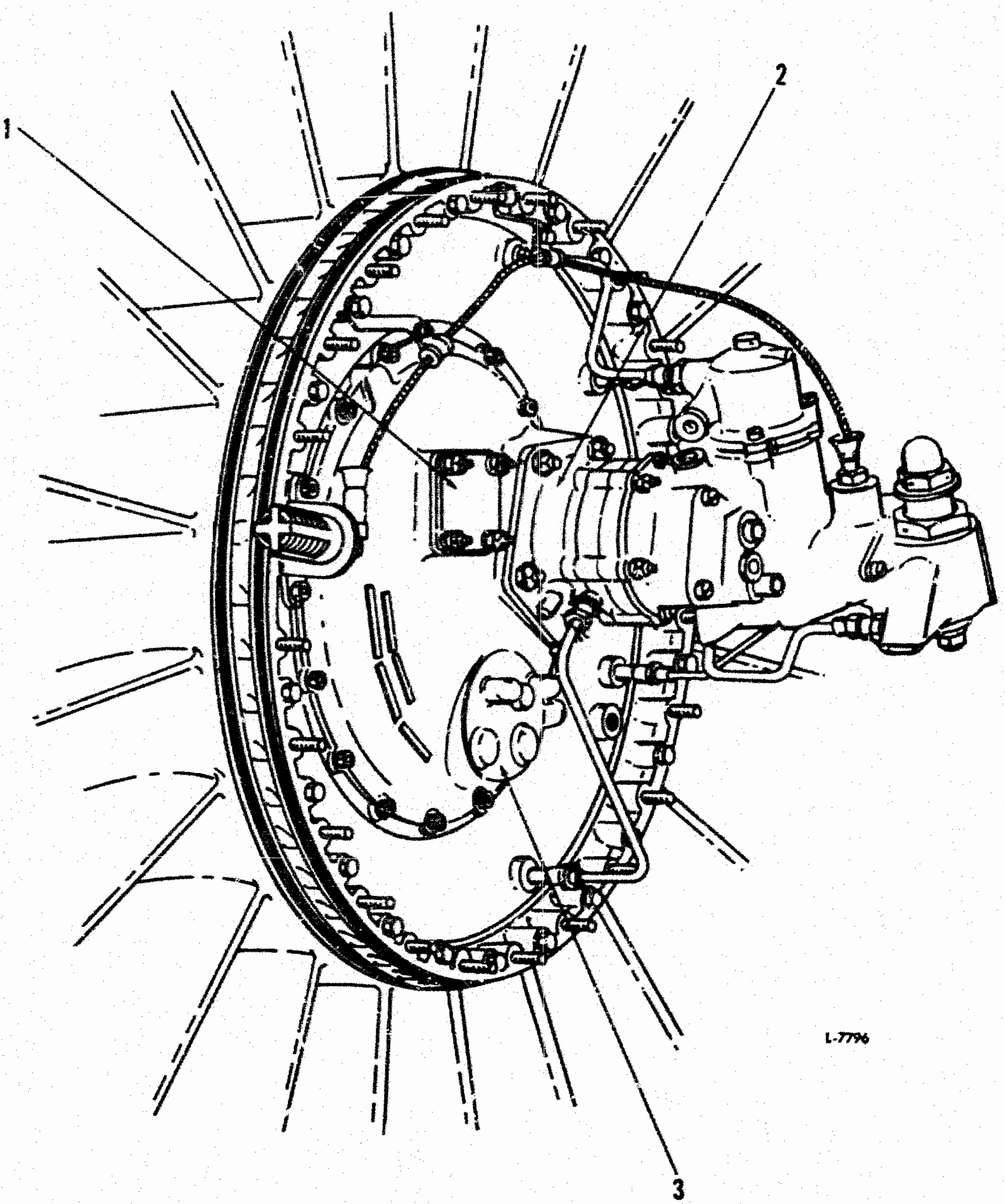
It is anticipated that the appearance of certain parts and procedures as they are described herein continue to be affected by design changes materializing too late for consideration in this publication. The latest available information concerning parts and procedures so affected will be included in subsequent revisions.

Front Accessory Section

See Figure 4.

The front accessory section consists of one assembly, the front accessory drive support. The case of this assembly is made of magnesium. Sixteen bolts secure the front accessory support to the number 1 Bearing support. The front accessory support has two mount pads on its front face. Later D-3 and D-3B engines have only one mount pad. Only one is used. This is the mounting and drive for the compressor bleed valve control (JT3D-1-MC6 and JT3D-1-MC7 - Temperature Biased). The other opening has provisions for mounting and driving a tachometer.

The No. 1 Bearing scavenge pump is mounted on its lower rear face of the support. Air and oil for the bleed control are brought out of the No. 1 Bearing support and tubed to the control. The front accessory drive gear which is externally splined, is inserted, with an "O" ring seal around it, into the front compressor front hub engaging the internal spline in the hub. In some engines the drivegear is retained by the No. 1 bearing inner race retaining nut; in other engines the drivegear is retained in the hub by a snapring and may be removed to permit internal rotor inspection without disturbing the bearing inner race retaining nut. The front accessory drive gear meshes with and drives the tachometer drivegear, the No. 1 Bearing scavenge pump drive gear, and the compressor bleed control drive gear.



1. TACHOMETER DRIVE PAD
2. COMPRESSOR BLEED CONTROL MOUNTING PAD
3. OIL SCAVENGE PUMP AREA

Front Accessory Section (Engines With Bleed Governor)

Figure 4

ENGINE - DESCRIPTION AND OPERATION

Front Compressor Section

Front Compressor Assembly

See Figure 5.

The front compressor, which is housed in the front compressor front and rear cases, consists of a rotor composed of eight rows of blades and a stator assembly containing eight rows of vane and shroud assemblies located between successive stages of blades. The first two rows of blades are considerably larger than the rest and are referred to as the "fan" blades.

There is no second stage stator, numbered as such, and also, there is no third row of blades. It is at this point that the air stream is separated into primary and secondary streams. The separation is achieved by the use of a spacer between the second and fourth stage blades. The primary air stream is directed internally by the third stage stator while the secondary air stream is exhausted through the exit struts. The numbering of the blade stage from front to rear is 1, 2, and 4 through 9, and the numbering of the stator stages is 1 and 3 through 8. The ninth stage stator vanes are incorporated in the intermediate case and will be discussed later.

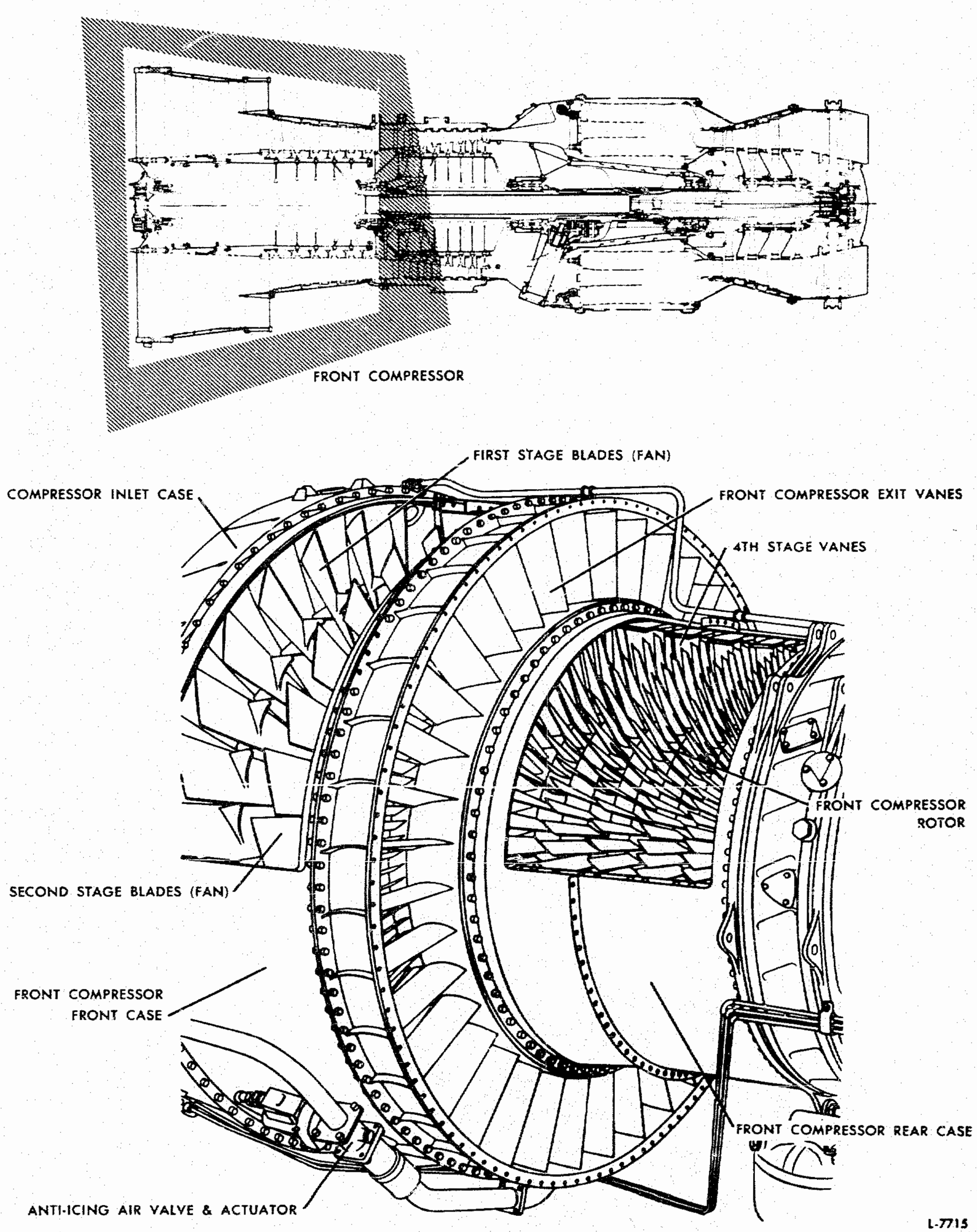
The third stage vane and shroud assembly is of single piece construction, whereas the fourth through the eighth stage are of the split type. The spacers of the fourth through eighth stage are integral. The inner shrouds form a seal ring for the two air seals on the outer diameter of each rotor disk spacer.

The compressor is driven by a shaft from the second, third, and fourth stage turbines. Its rotational speed is roughly two thirds the speed of the rear or high speed compressor. Its function is to provide the initial compression to the air that passes through the engine and transmit this air to the rear or high speed compressor. The stator vanes and rotor blades diminish in size and increase in quantity from the front to the rear of the compressor. This matches the decreasing volume of the air as the pressure of the air rises.

The front accessories are driven by a gear attached to the front hub of the front compressor rotor. The rear hub of the front compressor contains the front compressor drive turbine shaft coupling.

The rear hub of the front compressor rotor is supported by a double ball bearing (No. 2). The two halves of the No. 2 bearing (front compressor rear) are separated by an oil baffle in which drilled holes direct oil to the forward and aft sections of the double bearing. The No. 3 bearing (rear compressor front) inner race and rollers are mounted on the end of the rear hub. An oil seal on the rear end seals the bearing compartment from the engine air stream.

On the front hub, the rotor is supported by a roller bearing (No. 1), the liner of which is in the No. 1 bearing housing. An oil seal on the front end seals the bearing compartment from the engine air stream. The bearing support is secured to the inlet case assembly and forms the assembly which is discussed below.



Front Compressor Section

Figure 5

ENGINE - DESCRIPTION AND OPERATION

No. 1 Bearing Supports and Inlet Case Assembly

These assemblies are discussed together since the supports are mounted in the inner diameter of the inlet case assembly, the vanes of which, carry the structural load of the No. 1 bearing (front compressor front) from the inner shroud to the outer shroud.

The inlet case assembly consists of hollow titanium vanes, incorporating foam rubber stiffeners in the center bays, that are inserted between hollow, double walled titanium inner and outer shrouds. Each vane extends from the inner wall of the inner shroud to the outer wall of the outer shroud. Also, the vanes are welded to the outer wall of each shroud. There are holes in the side walls of the vanes that are between the shroud walls and this forms a passage for the flow of anti-icing air. The left and right anti-icing tubes feed heated air, when desired, into the outer rim of the shroud assembly opposite the eight and four o'clock struts.

Some of the vanes have tubes inside. These are for oil, breather and bleed valve control air lines. The No. 1 bearing oil pressure and oil return tubes are located in the seven o'clock and five o'clock struts respectively. The purpose of these vanes is to cause the air to enter the compressor rotor blades at the best angle for best compressor operation and to transport the structural load as discussed above.

The inner shroud, being of double-wall construction, provides for the passage of anti-icing air that has flowed inward through the guide vanes. The oil and air tubes that pass through the vanes have fittings mounted on the inner wall of the inner shroud.

On the front edge of the inner shroud, holes are drilled and tapped to hold the bolts that secure the No. 1 bearing housing and the compressor inlet air seal assembly. The No. 1 bearing housing holds the No. 1 bearing outer race and rollers in its ID. The front accessory front support is bolted to its forward face. Anti-icing air outlet holes are also on the front edge of the shrouds. The No. 1 bearing rear support, the inner section of which houses the No. 1 bearing oil seal, is bolted at its outer diameter to the compressor inlet vane inner shroud rear flange.

The outer shroud, being also of double-wall construction, provides for the passage of anti-icing air. The outer wall of the outer shroud forms the support for the outer fittings of the tubes that pass through some of the vanes. The anti-icing air inlet fitting is also in the shroud outer wall. A pressure probe fitting passes through both walls of the shroud to protrude into the air stream between the vanes. They are bolted to the outer walls.

The front rim of the outer shroud is drilled and tapped to receive the bolts which will hold the airframe air inlet duct. The rear rim of the outer shroud is drilled and tapped to receive the bolts that hold the shroud to the front compressor case.

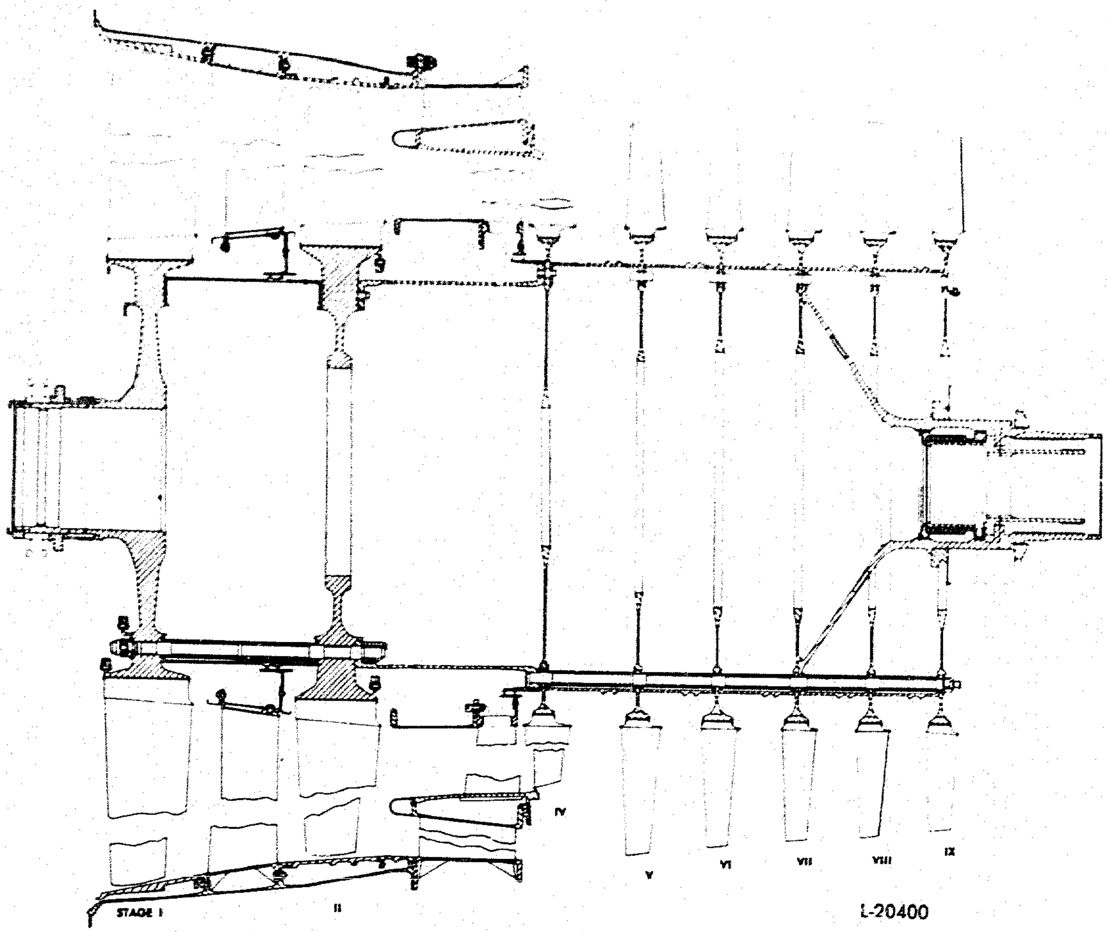
Front Compressor Cases

There are three front compressor cases namely: the front compressor case and vane assembly, the fan discharge case assembly, and the front compressor rear case assembly. These will be discussed individually below. The front compressor cases carry the structural load of the front of the engine. These cases decrease in diameter from front to rear to match the decreasing diameters of the stator rings.

Front Compressor Case and Vane Assembly

See Figure 6.

The front compressor case and vane assembly attaches to the rear flange of the compressor inlet case and the front flange of the fan discharge case. In the approximate center of the case, riveted to internal flanges, are the titanium first stage stator vanes. At the inner shroud of the vanes, a steel first stage air sealing ring is riveted. The inner shroud is constructed of titanium. From the forward internal flange to the inlet case, a front airflow duct is inserted. From the rearward internal flange to the fan discharge case forward flange, a rear airflow duct is inserted.



Front Compressor Rotor and Case Assembly

Figure 6

Fan Discharge Case Assembly

Attached to the rear flange of the front compressor case and vane assembly by bolts and pinned to the rear airflow duct, previously discussed, is the fan discharge case. This case is constructed of stainless steel and consists of an outer shroud and an inner case with thirty-eight steel ducts between them. The struts are secured in the inner case by a riveted locking plate at the rearward end and wired to the fairing retaining screws at the forward end.

Front Compressor Rear Case Assembly

Attached to the rear innermost flange of the fan discharge case and to the forward flange of the intermediate case is the front compressor rear case assembly. The front compressor rear case assembly is welded steel in construction. Welded to it internally are the supports for the vane and shroud assemblies. A center external flange serves as a reinforcement and is also used to support the brackets that carry external items.

Front Compressor Stator Vanes and Shrouds

The first stage stator vanes were discussed above under the front compressor case and vane assembly. There is no second stage stator. The third and fourth stage rows or stators are made of aluminum except fourth stage on MC-6 which is made of steel. These vanes are riveted into aluminum shroud rings. The fifth through eighth stator vanes are made of stainless steel and are welded into steel shroud rings. All the shroud rings are wide enough to form spacers which permit the compressor blades to rotate. The stators are pinned to inner shrouds to which are riveted inner air seal platforms. The third stage stator vanes and shroud are built into a single circular assembly which is held stationary by a flange inserted between the fan discharge case and front compressor rear flanges. The fourth through eighth stage stator vanes and shrouds are split and are prevented from rotating by being pinned to each other and to the third stage vane and shroud. When assembled, the rings are held in the engine by shoulders on the inside of the front compressor rear case.

The angle at which the vanes are mounted in the shrouds is set to feed air into the following row of rotor blades to give the best compressor efficiency at operating speed. Stator vanes decrease in size from front to rear to match the decreasing volume air and the decreasing size of the rotor blades.

Front Compressor Rotor

See Figure 6.

The front compressor rotor consists of two hubs, seven disks, seven spacer assemblies, eight rows of blades, two sets (sixteen each) of tierods and associated hardware. Each row of blades is inserted into undercut slots in its disk. They are held in place by locks inserted under the blades and bent to secure. The blades do not have a tight fit, but rather are seated by centrifugal force during engine operation. The front hub forms the disk for the first row of blades, but the rear hub is a separate unit that is held fast to the forward face of the seventh stage disk by the tiebolts. The spacers between the disks

are internally reinforced with tubes. The tiebolts run through these tubes and through the disks. These spacers have two knife-edges on their O.D. These run against the seal platforms on the stator vane inner shroud which was previously described. The exception to the above is the large spacer between the second and fourth stage compressor blades. This serves as a means of joining the "fan" section to the remainder of the compressor and in so doing, provides the needed space in that area. Each disk has twenty-four holes in its flange. Sixteen are for tierods and eight are for balancing weights when needed. The front hub has a lip on its forward face and the second stage disk has a similar lip on its rearward face to which balance weights can be added when the assembly is complete. The entire assembly is held together by the two sets of tiebolts. The smaller set holds the first two stages of blades together while the longer set holds the third through eighth stages together. Both sections are joined together by the spacer, as previously mentioned. The rotor blades decrease in size from front to rear. The first two stages of blades (fan) are considerably larger than the rest. The angle of each row of blades is set to give the best efficiency at operating speed. The rear hub flange has large holes to allow some ninth stage air into the compressor rotor. This air serves a dual purpose of providing bearing seal pressurizing and cooling. The front compressor rotor of the JT3D-1, and D-3 engines consists of hubs (front and rear) disks, and blades, all of which are made from titanium. On later JT3D-1, D-3, and D-3B engines, No. 2 Hub is made of steel. The first two stages of blades on the conversion engines (JT3D-1-MC6 and JT3D-1-MC7) are made from titanium. The fourth, fifth, and sixth stage blades (JT3D-1-MC7 only) and the seventh stage blades (JT3D-1-MC6 only) of the conversion engines are also made from titanium. The other stages of the conversion engines are made from stainless steel. There are two configurations of steel disk and blades used in the conversion engines; the difference being that the heavier design (JT3D-1-MC6) has thicker webs on the disks and hubs.

Compressor Intermediate Section

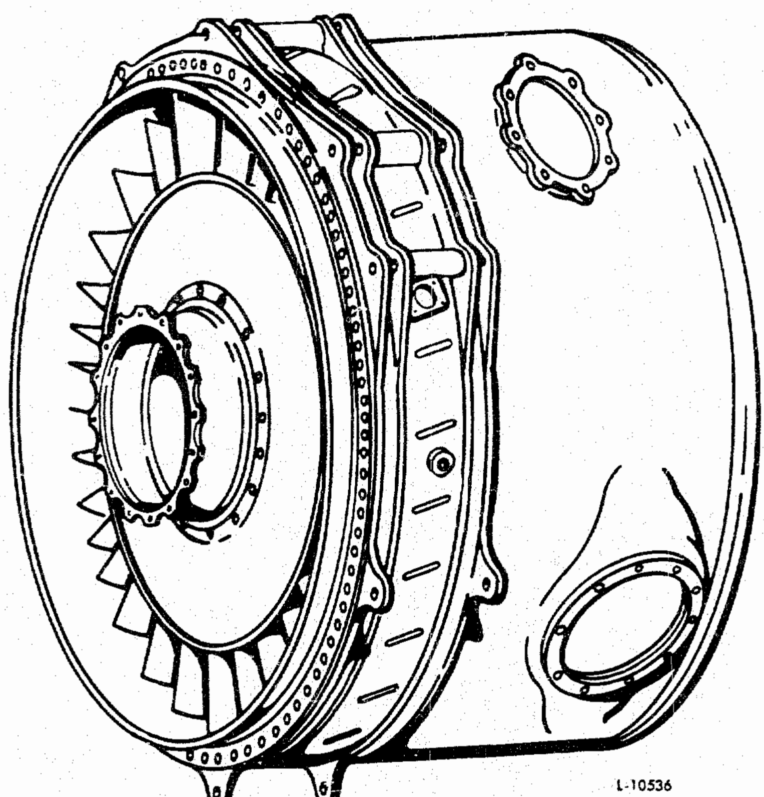
See Figure 7.

The forward mounting points are on the intermediate case which is attached to the rear flange of the front compressor case. A locating pin is used at top center between the two flanges. The intermediate case surrounds the rear compressor, but is not considered as part of it. It serves to separate the low pressure front compressor from the high pressure rear compressor and serves a structural function of joining the external cases. The intermediate case is of steel construction and has a double wall on the forward end. Guide vanes are welded from the outer wall, through the inner wall and extend into a shroud ring. The double mounting lugs are machined from rings. The case is welded to the rings. The front flange of the case is drilled and tapped for bolts that attach it to the front compressor case, and the rear flange is drilled. Nuts are spun into the holes for bolting the diffuser case and intermediate case together.

An oil breather pad is located between the mounting flanges at approximately the two o'clock position. An oil tube fitting is at the six o'clock position between the mounting flanges. Toward the rear of the case a hole is provided for air

bleeding and the air bleed valve mounting. On JT3D-1, D-3 and D-3B (Douglas) engines this is located in the upper left quadrant. On JT3D-1, D-3 and D-3B (Boeing), JT3D-1-MC6 and JT3D-1-MC7 engine, it is located in the lower left quadrant.

The thirty vanes that are on the inside front of the case serve as air inlet guide vanes to the rear compressor. They are hollow steel vanes with openings in their side walls at the outer end. These openings together with the double wall of the case, form the breather passage from the upper breather connections on the case to the lower opening. The lower opening connects directly to the main accessory case. Breather and oil tubes for the bearings located in the center of the case are through the hollow guide vanes. The inlet vanes are welded to the No. 3 Bearing support whose outer configuration is shaped to form an inner shroud ring for these vanes. At the front (inner) and rear (outer) ends of this support, bolt circles are provided to receive bolts to hold the diagonal and rear bearing supports. A hollow tubular seal is used at the rear (outer) bolt circle. The integral support described above, two round plates and the No. 2 Bearing housing hold the No. 2 1/2 Bearing. One of the round plates is flat and forms a diagonal brace between the front and rear support. The tapered plate has large holes at the top and bottom to allow air breather and passages for oil tubes. The extensions of the front and rear supports form the seal housings.



Compressor Intermediate Case (Typical)

Figure 7

ENGINE - DESCRIPTION AND OPERATION

The bearing housing is integral with the center support. A stepped edge seal ring is bolted to the support at the outer diameter of the rear support plate. This ring, together with its mating knife-edge seal minimizes air leakage out of the front end of the rear compressor. The area inside the ring and behind the rear support plate is exposed to high pressure air extracted from the twelfth stage of compression. The air pressure outside the seal ring is from the ninth stage.

Rear Compressor Section

See Figure 8.

The rear, or high, compressor is driven by a hollow shaft from the front stage turbine. Its function is to compress further the air delivered by the front compressor and then feed this air into the diffuser case and burners.

The rear compressor consists of a stator having six rows of vanes and a rotor having seven rows of blades. The exit guide vanes are mounted in the diffuser section. In function, these are part of the compressor, but because of their structural location, we will discuss them under the diffuser.

Vane and Shroud Assemblies

See Figure 9.

There are six vane and shroud assemblies in the rear compressor. The vanes reduce in height from front to rear of the compressor. The outer side diameter of the air passage formed by these assemblies is constant, the decreasing size of the vanes is accomplished by increasing the diameter of the inner shroud rings. The vanes are steel and are brazed to the inner shroud and pieced through the outer shrouds on the first five vane and shroud assemblies, the spacers separating the assemblies are integral. The sixth stage does not provide spacing. However this is furnished by the seventh stage located in the diffuser case. Between each shroud, dowel pins are used to lock the series of shrouds together. The rear shroud, (seventh) is pinned to the seventh stage outer shroud to prevent rotation. An edge of each spacer rests against a case shoulder to center the assembly.

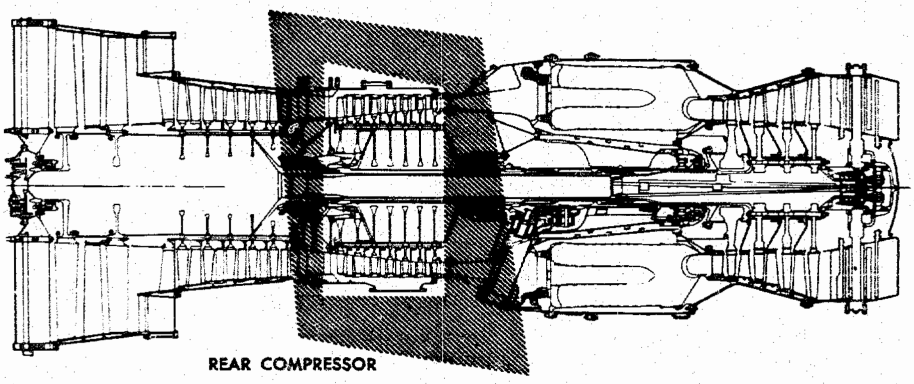
Air Seals

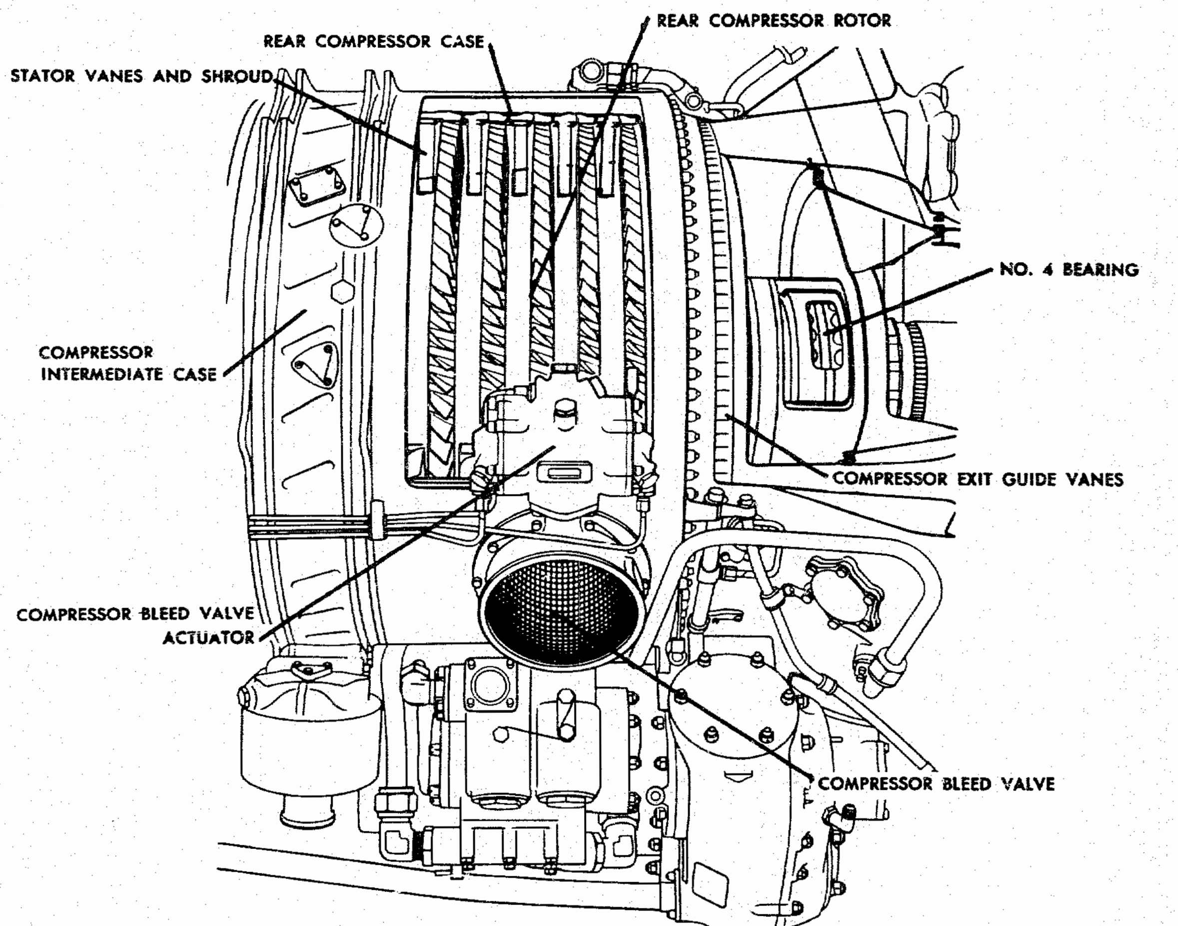
The inside shroud of each row of vanes has a steel ring, with a small step on its inside face, riveted to it. Two knife-edge seals on each rotor spacer rides free of the steps forming an air seal between the compressor stages.

Rear Compressor Rotor

See Figure 10.

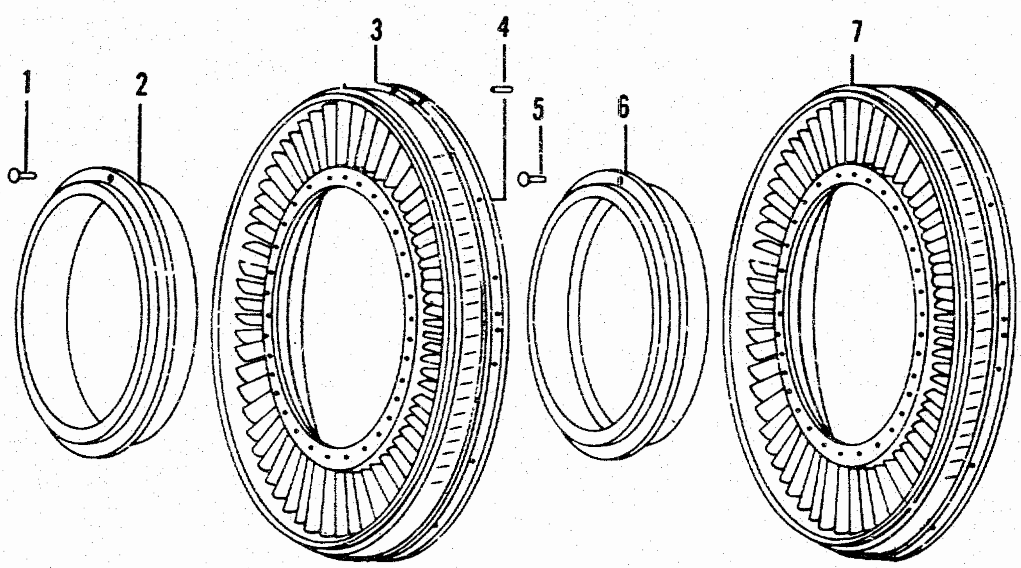
The rotor consists of seven rows of blades on disks; two hubs, six spacer assemblies, sixteen tierod bolts with nuts and washers. A knife-edge seal ring is





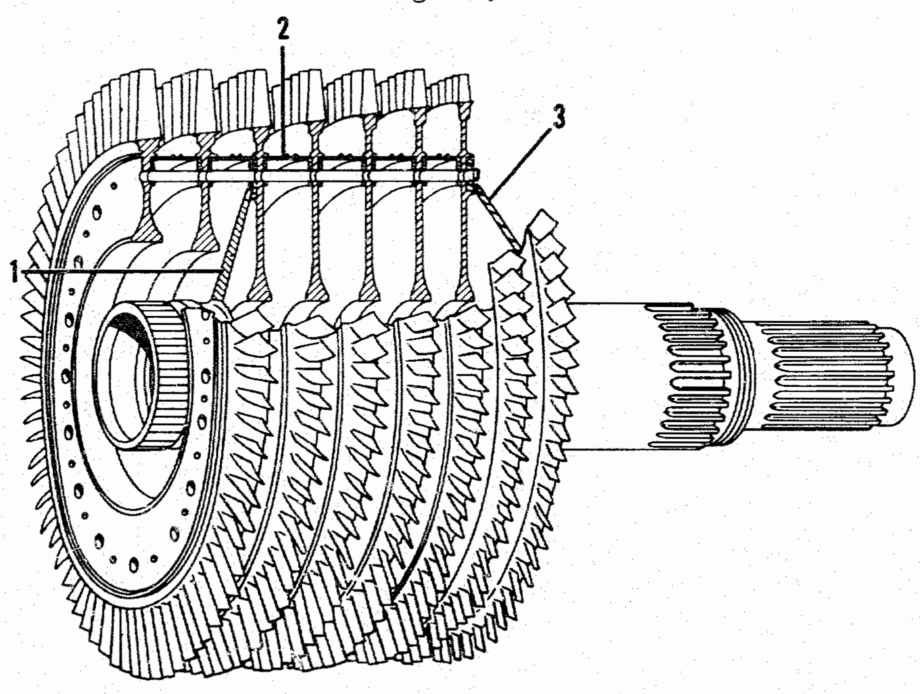
Rear Compressor Section

Figure 8



1. RIVET
2. AIR SEAL RING
3. 10th STAGE VANE & SHROUD ASSEMBLY
4. PIN
5. RIVET
6. AIR SEAL RING
7. 11th STAGE VANE & SHROUD ASSEMBLY

Rear Compressor Vanes and Shrouds
Figure 9



1. FRONT HUB
2. SPACER ASSEMBLY
3. REAR HUB

Rear Compressor Rotor
Figure 10

riveted to a lip on the forward face of the tenth stage disk. This seal ring rides free of the platformed seal which was referred to in the compressor intermediate case discussion.

Each row of blades is inserted into undercut slots in its disk. (See Figure 11). They are held in place by locks inserted under the blades and bent to secure. The blades do not have a tight fit, but rather are seated by centrifugal force during engine operation.

Every disk has thirty-two holes in its flange. Sixteen are for tiebolts, and sixteen are for balancing weights when needed. The entire assembly is held together by tiebolt heads on one end and a nut and washer on the other end.

The spacers between the disks are internally reinforced with tubes (See Figure 12). The tiebolts run through the tubes and the spacer internal flanges as well as the disk flanges.

Neither the front nor rear hub is integral with a disk. The front hub is attached to the front face of the third disk and the rear hub to the rear face of the last disk. The hubs are secured to the rotor assembly by the steel tiebolts mentioned above. A steel tube runs from one hub to the other inside the rotor.

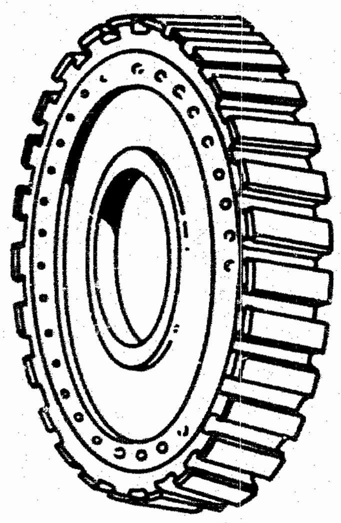
The tube is a force fit into the inside diameter of both hubs and permits breathing within its inside and keeps twelfth stage pressure air from the No. 3 and No. 4 1/2 Bearings.

The front seal was discussed previously. If required, a balance weight may be riveted to it.

The third spacer from the front has holes drilled in it. Through these holes twelfth stage air is bled into the rotor center where it is bled through holes in the front hub. The air is directed forward to the space just behind the No. 3 Bearing rear support plate and pressurizes the No. 3 Bearing oil seal. Since there are no holes in the rear hub disk the pressure of the air against this disk counteracts part of the rotor forward thrust.

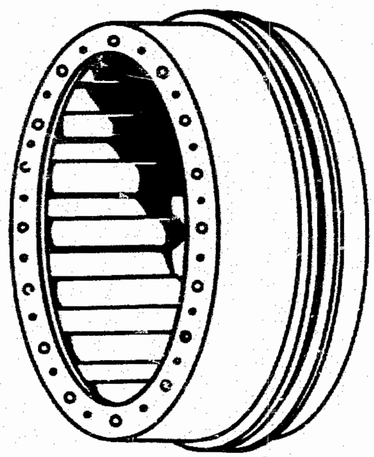
The rear compressor case carries no structural bearing loads and is thus made of relatively thin sheet metal. Its purpose is to hold the stator parts of the compressor and act as an air separator. The air pressure increases from front to rear and finally becomes sixteenth stage pressure. Between this case and the intermediate case which envelopes it, the pressure is ninth stage air. The case has a flange at its rear end to which the screws that attach the case to the diffuser section are secured. Also, bolt holes are provided to hold the intermediate case to the diffuser section.

ENGINE - DESCRIPTION AND OPERATION



L-5204

Rotor Disk
Figure 11



L-5205

Rotor Disk Spacer
Figure 12

Diffuser Section

See Figure 13.

General

The velocity of the air as it leaves the rear compressor is very high. This motion is both rearward and tangential around the ending. Exit guide vanes at the forward end of the diffuser case convert the tangential whirl into pressure energy. After the vanes, the high pressure air will have a large rearward velocity. The gradual increasing area of the air flow passages provided by the diffuser case configuration decreases the air flow velocity to a suitable burning speed and increases the pressure.

Diffuser Case

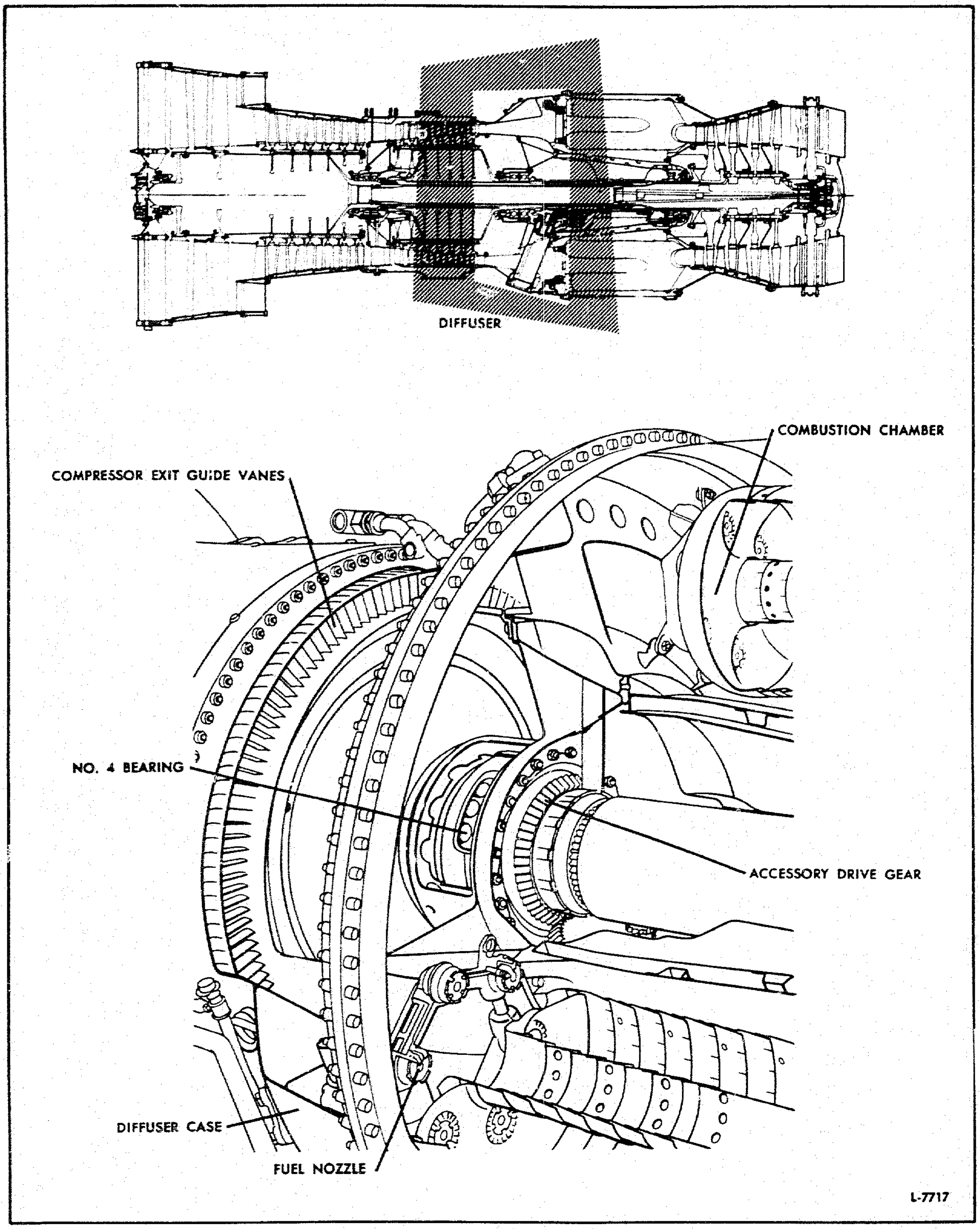
See Figure 14.

The diffuser case is of welded corrosion and heat resistant steel construction with drilled flanges at both ends for bolting to the rear compressor and intermediate cases in the front and the combustion chamber case in the rear.

The pad at the top center of the case is used for a breather connection. This leads to the bearing area through a strut. Air bleed outlet pads are on the outside of the case. An opening with mounting bosses at the bottom of the case provides for the angled accessory drives system and the accessory drive adapter which transmits high rotor motivation to the accessory drives gearbox assembly. The rearmost pad at the bottom center of the diffuser case is for mounting the fuel pressurizing and dump valve which is attached outside the case. The fuel manifolds attach to the inside of the case at this pad. The fuel manifold inlet distributor which connects to the fuel pressurizing and dump valve passes through a hole in the case at this location.

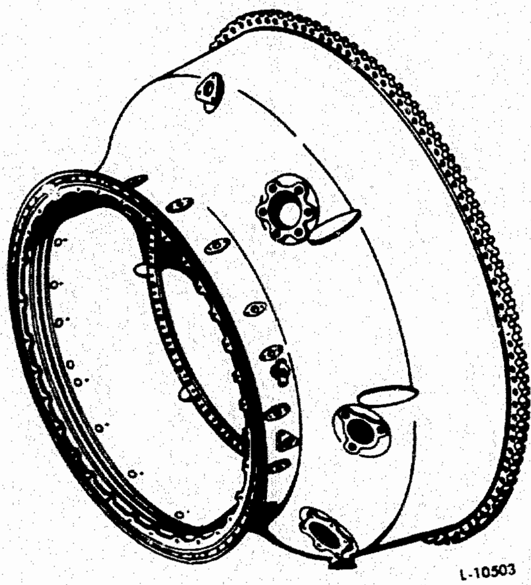
Two forward facing and one rear facing bolt rings are mounted on the struts from the outer case. Sheet metal between these bolt rings and on the inside and outer case add to strength and form the gradually increasing cross section of the diffuser. A slightly tapered diffuser inner inlet duct is bolted between an inside flange on the inlet guide vane inner shroud and the outer, forward facing, bolt circle inside the diffuser case. This piece forms a part of the diffuser ducting. The rivet circle that holds the diffuser inner inlet duct to the inlet vane ring extends forward to ride over two knife-edges that are on the rear disk of the rear compressor. This forms the air seal between the rear compressor and the bearing housing area at the center of the diffuser case. The outer shroud flange is clamped between the diffuser case and the rear compressor case when these units are assembled.

The water injection nozzles (JT3D-1, D-3 and D-3B Boeing, and JT3D-1-MC6) are mounted around the periphery of the diffuser case. The nozzles permit the entry of water into the highly compressed air stream, thereby increasing its



Diffuser Section

Figure 13



Diffuser Case
Figure 14

density and lowering its temperature prior to injection of the fuel from the fuel nozzles.

Water Injection Manifold (Optional JT3D-1, D-3 and D-3B Boeing, and JT3D-1MC6)

The water injection manifold is the split type which is mounted on the diffuser case front flange. The water is dispersed through the sixteen curled tubes mounted on the periphery of the diffuser case. The elbows of the tubes are aligned to the sixteen holes in the diffuser case. Water is metered from the water injection control through a supply tube to the tee fitting on the diffuser case front flange. Water then flows through the manifold into the air stream in the diffuser case.

No. 4 Bearing Housing

The No. 4 Bearing is in the diffuser section. This supports the rear compressor rear hub. The bearing housing and its seal are fastened to the forward facing inner bolt ring with studs and nuts. A synthetic rubber gasket is used just inside of the stud circle.

Oil Pump and Gearing

See Figure 15.

The No. 4 and No. 5 Bearing scavenge pump and the accessory drive gears are in the lower rear of the diffuser case.

Brackets

A quantity of brackets are attached to the external bolt circles for mounting external tubing and units.

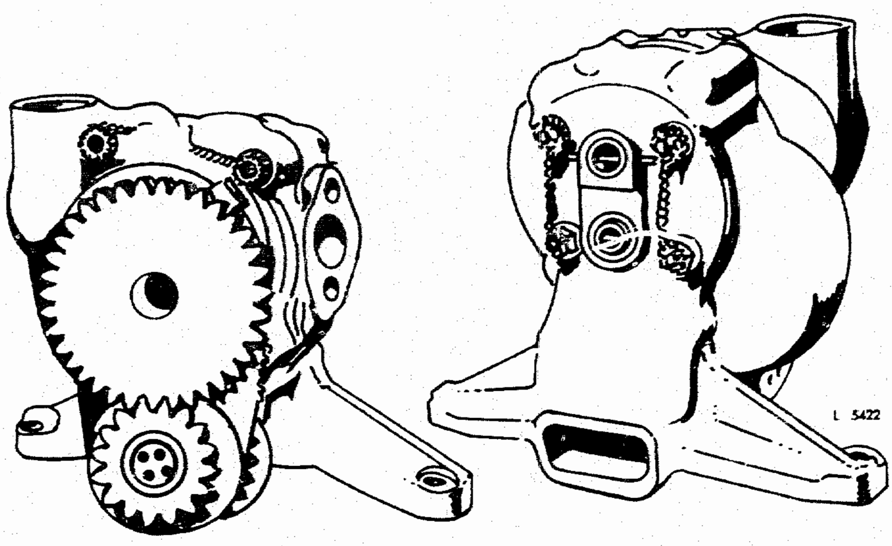
Fuel Manifold Attachment

As viewed from the rear, sixteen brackets are welded to the inner structure of the diffuser. These brackets, and brackets that are welded to the inside rear of the diffuser outer case, support the fuel manifold.

Fuel Manifold

See Figure 16.

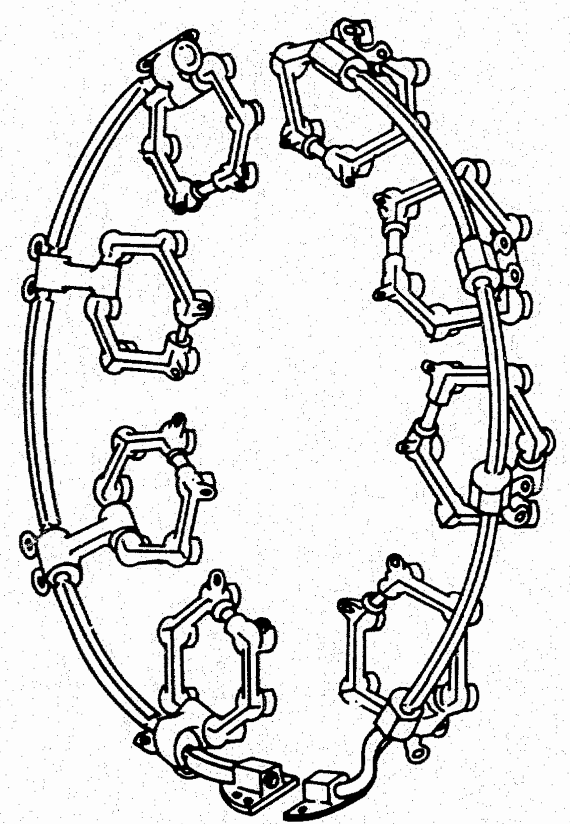
The fuel manifold is split at the inner flange and between the number one and eight clusters. The manifold assembly consists of a primary and a secondary fuel manifold and eight clusters of fuel nozzles. There are six fuel nozzles



No. 4 and No. 5 Bearings Oil Scavenge Pump

Figure 15

ENGINE - DESCRIPTION AND OPERATION



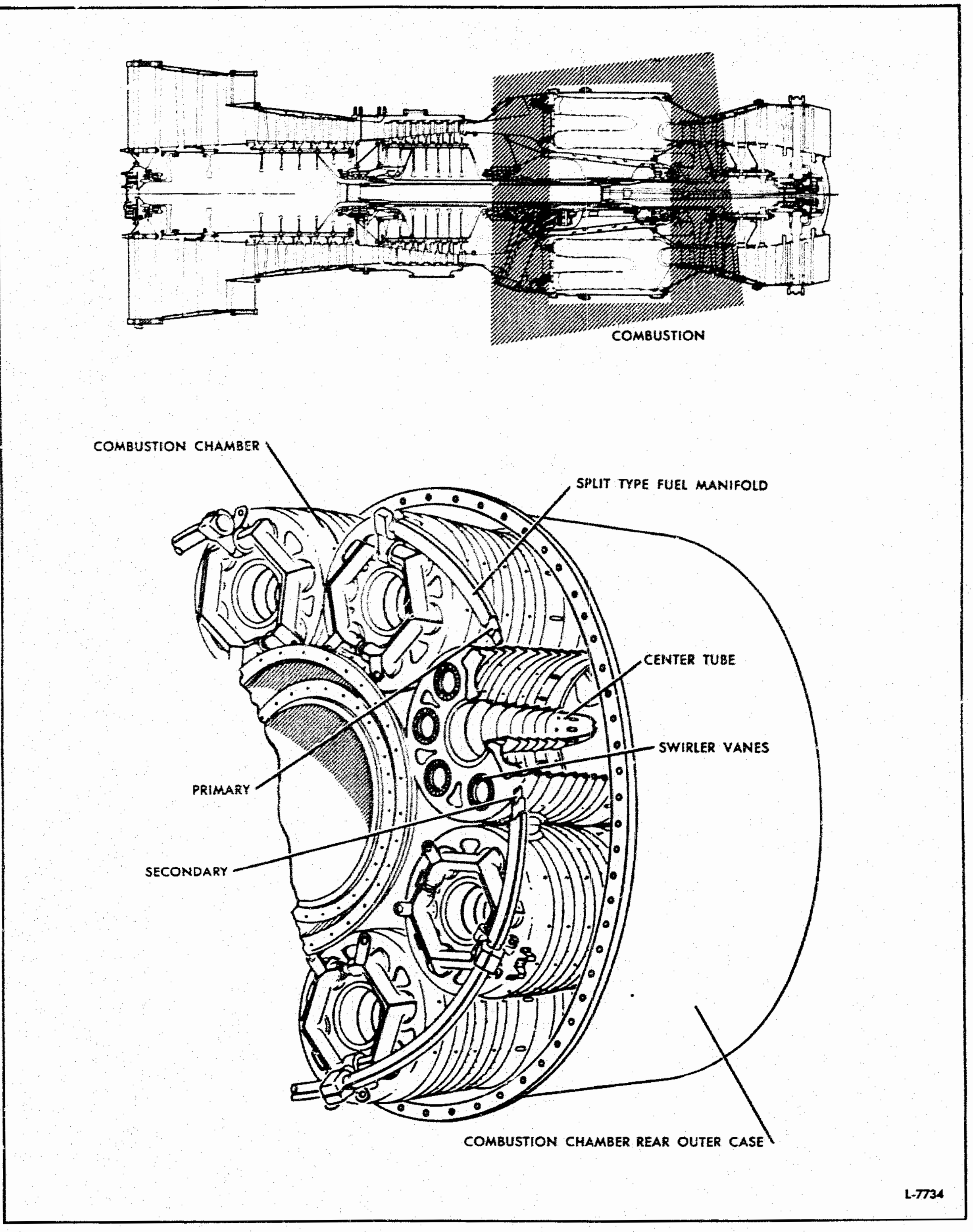
Fuel Manifold
Figure 16

in each cluster. The fuel manifold incorporates mounting lugs in the inner and outer diameter which are secured to the rear face of the diffuser case. Eight combustion chamber positioning brackets are mounted on the outer diameter mounting lug locations. See Chapter 73.

Combustion Section

See Figure 17.

The combustion chamber outer case is secured at the front flange to the rear flange of the diffuser case and at the rear flange to the turbine nozzle case. Eight combustion chambers, often called burner cans, the combustion chamber inner case, the No. 5 bearing support, and the No. 5 bearing housing are located inside the combustion chamber outer front case.



Combustion Section
Figure 17

ENGINE - DESCRIPTION AND OPERATION

Combustion Chamber Outer Cases

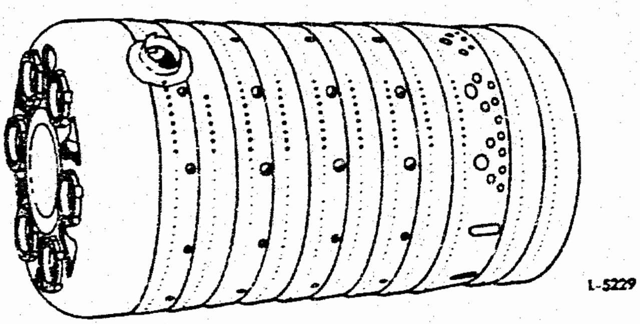
There are two combustion chamber outer cases, the front and the rear. They are constructed of corrosion and heat resistant steel. The front flange of the combustion chamber outer front case is bolted to the rear flange of the diffuser case. The front flange of the combustion chamber outer rear case is bolted to the rear flange of the outer front case and rear flange to the front flange of the turbine nozzle case. The outer rear case rear flange is internal. It lies behind the forward external flange of the turbine nozzle case and bolts to it. Thus, the outer cases (if bolted together) or the rear outer case can be slid rearward over the turbine nozzle case to give access to the combustion chambers. The outer front case has interlocking lips on its flanges to provide sealing when joined.

Combustion Chambers

See Figure 18.

The combustion chambers are radially housed inside the combustion chamber outer case. The forward face of each combustion chamber presents six apertures which align the six nozzle of the corresponding fuel nozzle cluster.

There are four basic types of combustion chambers in service. Combustion chambers Type I and II are interchangeable. However, Types I and II are not functionally interchangeable with Type III chambers. Type III (Modified) chambers (smokeless burner configuration) are not functionally interchangeable with Types I, II, or III. Within Types I and II, chamber number 1, 3, and 7 are interchangeable and numbers 2, 6, and 8 are interchangeable. In Types III and III (modified), chamber number 2 and 3 are interchangeable and numbers 6, 7, 8 are interchangeable. Numbering is clockwise, as viewed from the rear, and starts with the one o'clock position chamber. Chambers number 4 and 5 have sparkigniter sleeves and guides, and chamber number 4 has an air pressure transfer tube in it. Interconnecting flame tubes join all the chambers around the circle. The tubes on the odd numbered Type I and II chambers are female and have an air shield on the upstream side that overlaps the mating male flame tube. In Type III and III (modified) chambers, the number one chamber has female interconnecting flame tubes; the number five chamber has male tubes and chambers number 2, 3, 4, 6, 7, and 8 have one male and one female flame tube. When removing Type I and II chambers, the even numbered chambers must be removed first. The removal sequence for Type III and III (modified) chambers is number 5, 6, 4, 3, 7, 2, 8, and 1.



Combustion Chamber
Figure 18

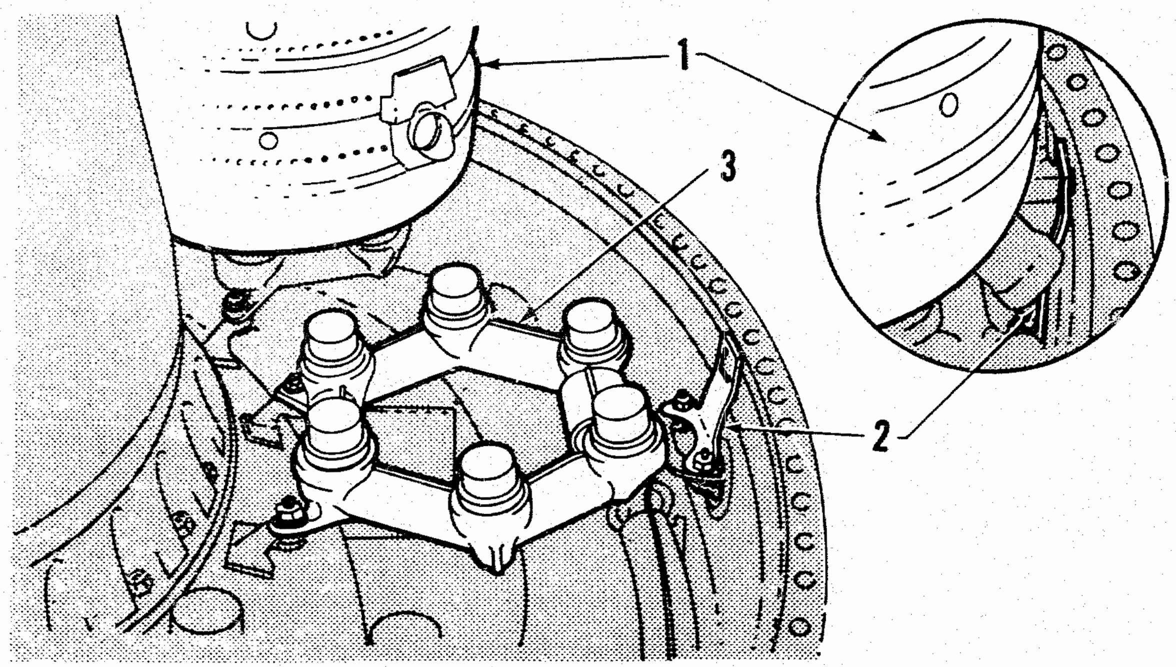
ENGINE - DESCRIPTION AND OPERATION

The combustion chambers are a welded assembly. At the head of each chamber are six air swirl fuel nozzle guides through which six fuel nozzles fit. These guides are fitted with cast toroidal deflectors which reduce carbon buildup on fuel nozzles and thus reduce subsequent turbine air seal wear. The holes in the walls of the chamber meter the entering air. Near the head of the chamber most of the air is used as combustion air. Further down the chamber the entering air is used to cool the hot gases to safe temperature for the chambers. The rows of smaller holes admit air that cools the can itself.

Each chamber is held in place by a positioning bracket (see Figure 19) and a clamp (see Figure 20). The clamp holds the open end of the chambers to an outlet duct assembly which is fastened to the turbine case. Each positioning bracket is secured by two outer fuel manifold retaining bolts. The bracket hooks onto a retaining lug on the combustion chamber. The fuel nozzle inside the air swirl guide holds the chamber from lateral movement.

Fireseal

The fireseal is held by the bolts that join the front and rear combustion chamber outer cases. The outer rim of the fireseal fits tightly against the engine pod. The JT3D-1, D-3 and D-3B (Boeing), the JT3D-1-MC6, and JT3D-1-MC7 engines use the narrow band type (see Figure 21) fireseal, while the JT3D-1, D-3 and D-3B (Douglas) uses the offset lip type.

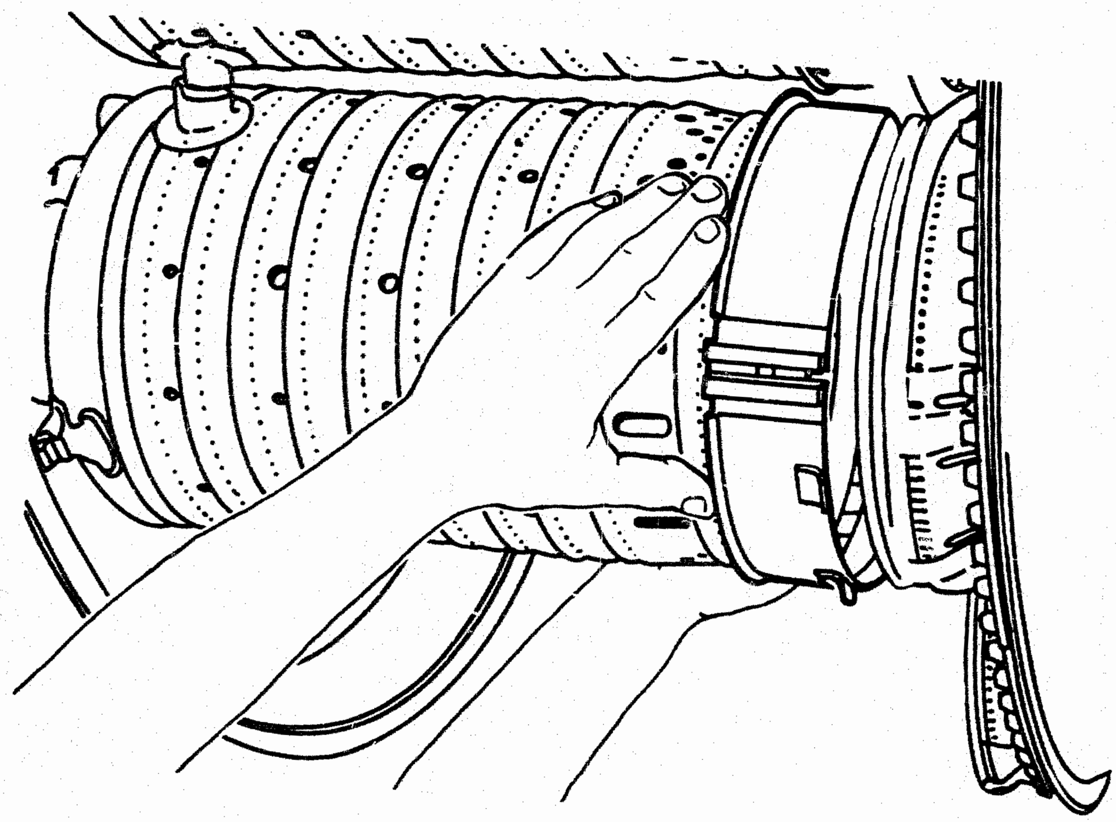


1. COMBUSTION CHAMBER
2. COMBUSTION CHAMBER POSITIONING BRACKET
3. FUEL MANIFOLD CLUSTER

L-6423

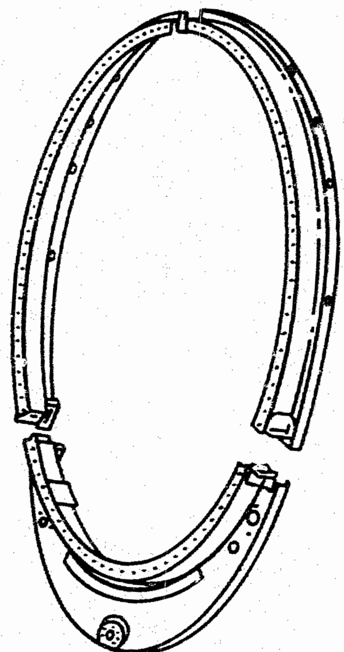
Combustion Chamber Positioning Bracket

Figure 19



L-5338

Combustion Chamber Clamp
Figure 20



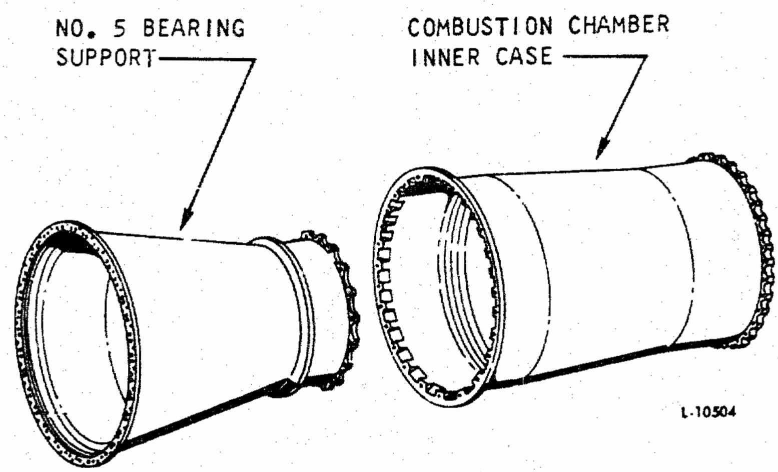
L-5252

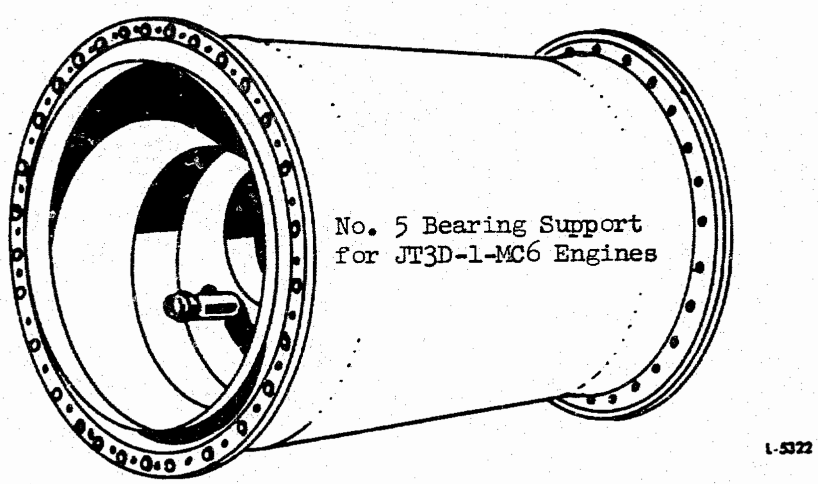
Fireseal (Narrow Band Type)
Figure 21

The Combustion Chamber Inner Case

See Figure 22.

The combustion chamber inner case is made of corrosion and heat resistant sheet steel with reinforcements welded to its inside surface. Its prime function is to form the inner surface of the combustion section, but together with the No. 5 Bearing support, it provides an inner passage for the sixteenth stage air which will help cool the radiant heat from the combustion chambers. Holes in its forward flange, the diffuser, and the No. 5 Bearing support permit this air to flow. A flange on the rear end attaches to the turbine nozzle inner case.





No. 5 Bearing Support and Combustion Chamber Inner Case

Figure 22

No. 5 Bearing Support

See Figure 22.

The No. 5 Bearing support is made of corrosion and heat resistant sheet steel with reinforcements welded to its inside surface. An inner wall is also welded to it. Its prime function is to support the No. 5 Bearing and its seal and provide an inner passage for the No. 5 Bearing pressure and scavenge tubes and the turbine shafts. The forward flange of the support bolts to the inner rear facing bolt circle of the diffuser. Together with the combustion chamber inner case, it forms the cooling air passage described above. Space is provided in the bottom of the support for the No. 4 and No. 5 Bearing scavenge pump. Between the inner and outer wall, the pressure and scavenge tubes for the No. 5 Bearing are located.

No. 5 Bearing Support (JT3D-1-MC6 - Prior to S.B. 765)

See Figure 22.

This single piece unit is of dual wall construction since it serves the double function of acting as the combustion chamber inner case (its outer wall) as well as supporting the No. 5 Bearing and its seal. A heatshield on its inner surface separates the sixteenth stage air from the radiant heat of the combustion chambers. It contains passages for the No. 5 Bearing oil scavenge and pressure tubes. The No. 5 Bearing is secured to the rear face of the diffuser case. The No. 5 Bearing housing is attached to the rear of the support.

Turbine Section

See Figure 23.

The turbine section consists of a four stage gas turbine. The first stage rotor, also called the high speed turbine, drives the rear compressor. The second, third, and fourth stage rotors, also called the low speed turbine, are mounted on a single shaft which drives the front compressor.

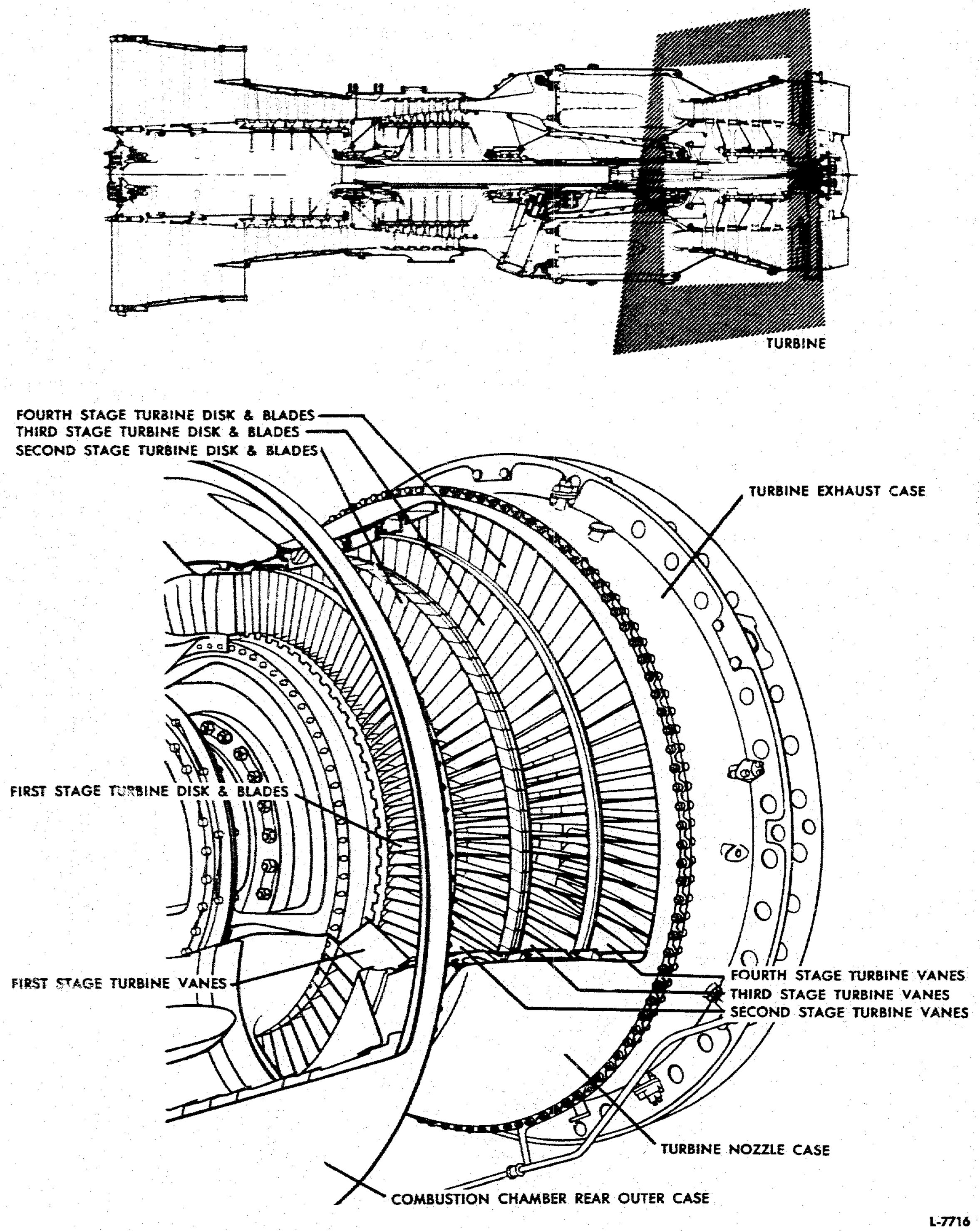
Turbine Nozzle Outer Case

See Figure 24.

The turbine nozzle case is constructed of corrosion and heat resistant steel for single piece construction or for welded construction. On its front flange, gang bolt assembles are attached, and this flange bolts to the combustion chamber outer case. The rear flange bolts to the turbine exhaust case using a spacer ring. Inside the turbine case, slots and ridges are machined and stator vanes and seals are inserted in these locations.

Turbine Nozzle Inner Case

The turbine nozzle inner case is constructed of nickel alloy steel. On the JT3D-1 and JT3D-1MC7 engines, the front end of the case is attached to



Turbine Section

Figure 23

the rear flange of the combustion chamber inner case. On the JT3D-1-MC6 engine, the front end is attached to the rear flange of the No. 5 Bearing support. At the outer rear end, two shoulders hold the inner end of the first stage turbine vanes. The front (largest) shoulder has pins for securing the vanes. On the ID of the inner case, there are two knife-edged air seals. The innermost seal is riveted to a support welded to the approximate middle of the inner case. It rides free of an inner platform on the first stage turbine disk. The outer air seal is riveted to the rear of the inner case. It rides free of an outer platform on the first stage turbine disk.

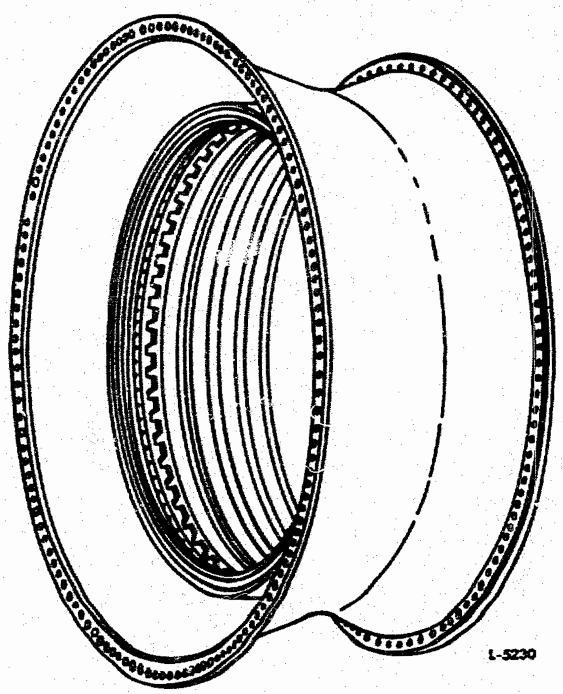
Combustion Chamber Outlet Duct

See Figure 25.

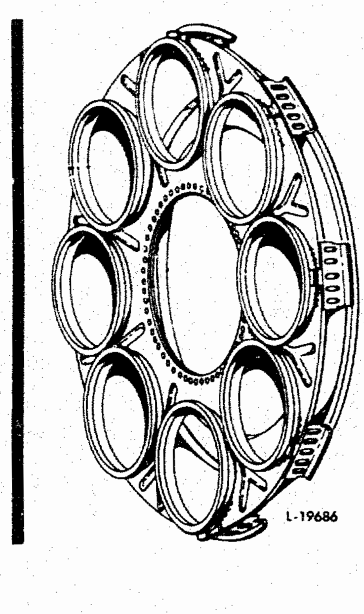
This duct guides the hot gases to the first stage nozzle. It is retained to the No. 5 Bearing support. The duct is a welded assembly that is held in place by the combustion chamber outer case-to-turbine nozzle case bolt circle. The forward flanges of the duct ports carry the rear edge of the clamps that hold the combustion chambers in place.

Turbine Vanes, Shrouds, and Seals

First Stage Vanes are cast from corrosion and heat resistant alloy with chromalize protective coating on all internal and external cast surfaces. Second, third, and fourth stage turbine vanes are cast from corrosion and heat resistant alloy. First Stage Vanes are held by pins between the recesses



Turbine Nozzle Outer Case
Figure 24



Combustion Chamber Outlet Duct
Figure 25

in the outer turbine case and are snapped onto their pins in the turbine nozzle inner case assembly to seat on the shoulders of the case. A later configuration of first stage nozzle vane is bolted to the turbine stator support assembly.

A seal and a spacer are placed in the outer case just to the rear of the first stage vanes. One knife-edge on the first stage turbine blade shroud runs between the seal's two knife edges.

Second stage turbine vanes fit into the outer case just behind the first seal spacer. Extensions on the root platform of each vane hold them in place on their forward edges and a lockring is used at the outer rear edge. The inner end of these vanes slip into slots in the shroud ring. The inside edge of the shroud ring has a turbine inner seal riveted to it. The seal ring carries four knife-edges on its inside flange. One of these knife-edges run free against the shoulder on the rear compressor drive turbine disk and the remaining three (rearmost) against flange face of the front compressor drive turbine hub. This forms a seal between the front and second stage rotors to force the working gases to pass through the second stage vanes. A lockring, a stepped seal, and a seal spacer are in the outer case following the second stage vanes. The two knife edges of the second stage blade run free against the stepped seal. Mounting of the third stage turbine vanes is the same as the second stage. The inner seal ring, however, instead of having knife-edges has a stepped platform. The knife-edges are on the spacer between the second and third stage turbine disks. There are six of them set in pairs. Mounting of the fourth stage turbine vanes is identical to the third stage. The outer seal is stepped and extends into the turbine exhaust case. There is no locking ring, but the fourth stage vanes are held in the rear by the stepped seal which is held by its flange that fits between the turbine nozzle case and the turbine exhaust case flanges.

Rear Compressor Drive Turbine Rotor

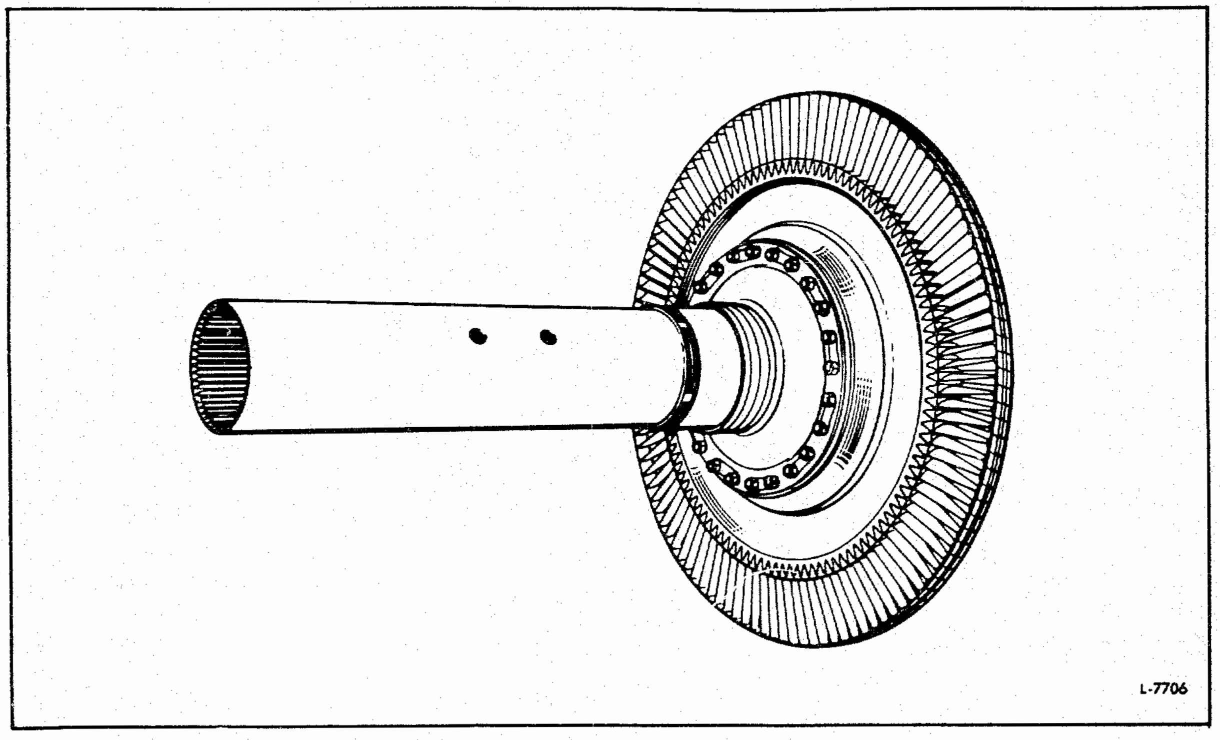
See Figure 26.

The rear compressor drive turbine rotor consists of a disk, blades and a shaft. The No. 5 Bearing inner race and seal assembly are located forward of the disk and secured on the shaft by a nut, a tabwasher, and a lockring at assembly. The turbine shaft splines into the rear compressor rotor and is secured to the rotor hub by the rear compressor drive turbine shaft coupling. The outer race of the No. 4 1/2 Bearing is located inside the turbine shaft.

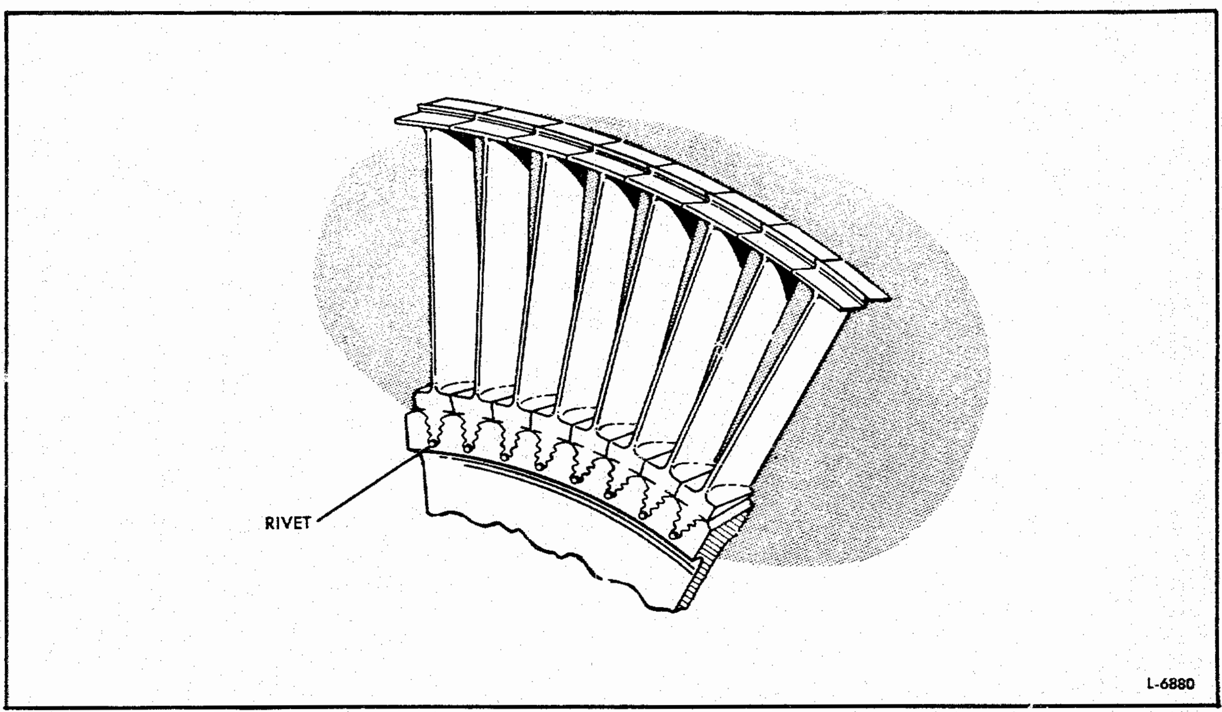
Turbine Blades

See Figure 27.

The blades are made of forged nickel alloy. The blades have "fir tree" serrations as their roots. The blades can only be inserted by a forward and rear movement and are held in place by a rivet at the bottom of the "fir tree". The working part of the blade is a curved surface that changes the direction of the swiftly moving gases that pass over it. The reaction of these gases to change in direction of travel produces the force that turns the turbine rotor.



Rear Compressor Drive Turbine Rotor
Figure 26



Turbine Blades
Figure 27

ENGINE - DESCRIPTION AND OPERATION

At the outward end of each blade is a wide flat section called a shroud. This shroud prevents gas leakage at the blade ends. Each blade has a stepped arrangement by which they lock to each other, and this forms a complete shroud ring when assembled. This ring gives the rotor greater strength as well as making up a gas seal. Because of the particular construction, it is impossible to remove one turbine blade only, and at least half of the blades at 90 degrees on either side must be removed. A staggered movement of all these blades must be made before the center blade "fir tree" will clear the disk. There are 130 blades in the first stage turbine rotor.

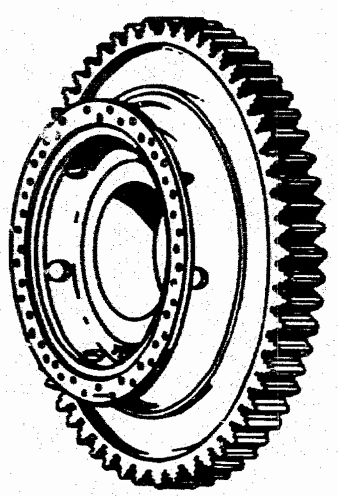
Turbine Disk

See Figure 28.

The disk is made of corrosion and heat resistant steel. A drilled flange on the front face of the disk is bolted to the rear end of the rear compressor drive turbine shaft. Balance holes in the disk flange are also provided. "Fir tree" serrations are cut in the rim matching the serrations in the turbine blades.

Turbine Shaft

The shaft is hollow with internal splines at its front end which mate with external splines of the rear compressor rear hub. Turbine position in the turbine nozzle case is determined by a spacer ring that is between the end of the compressor hub shaft and an internal shoulder in the turbine shaft.



L-5334

Turbine Disk

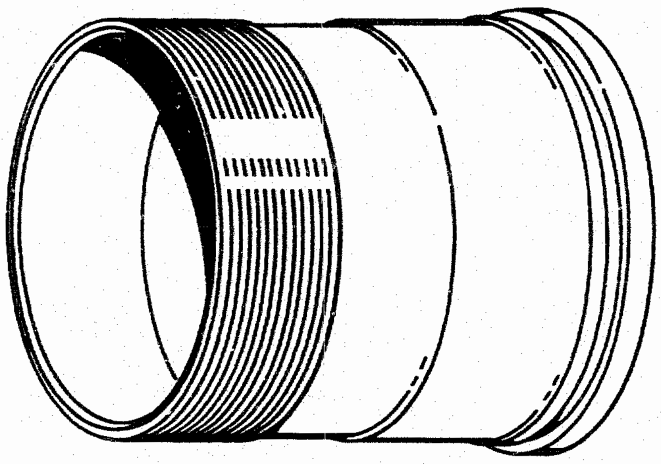
Figure 28

ENGINE - DESCRIPTION AND OPERATION

Coupling

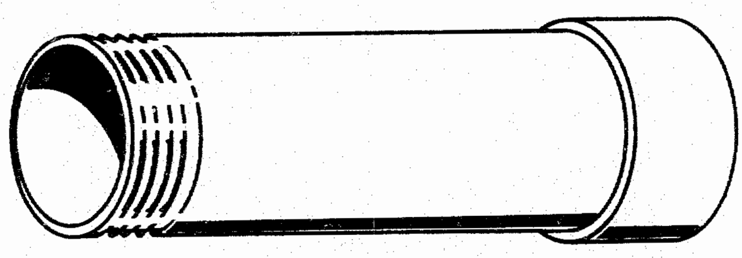
See Figures 29 and 30.

A coupling holds the turbine shaft and the compressor rear hub together. Outside threads on the forward end of the coupling mate with threads on the inside of the compressor hub shaft, and a shoulder on the outside of the coupling butts against an internal shoulder in the turbine drive shaft. An internal spline at the rear of the coupling is used for wrenching. On the JT3D-1 and JT3D-1-MC7 engine, the coupling is locked in with a jamnut having a left hand thread. On the JT3D-1-MC6 engine, the coupling is locked by the No. 4 1/2 Bearing outer race and liner.



L-7060

Coupling (JT3D-1, D-3, D-3B, and JT3D-1-MC7)
Figure 29



L-5406

Coupling (JT3D-1-MC6)
Figure 30

ENGINE - DESCRIPTION AND OPERATION

Front Compressor Drive Turbine Rotor

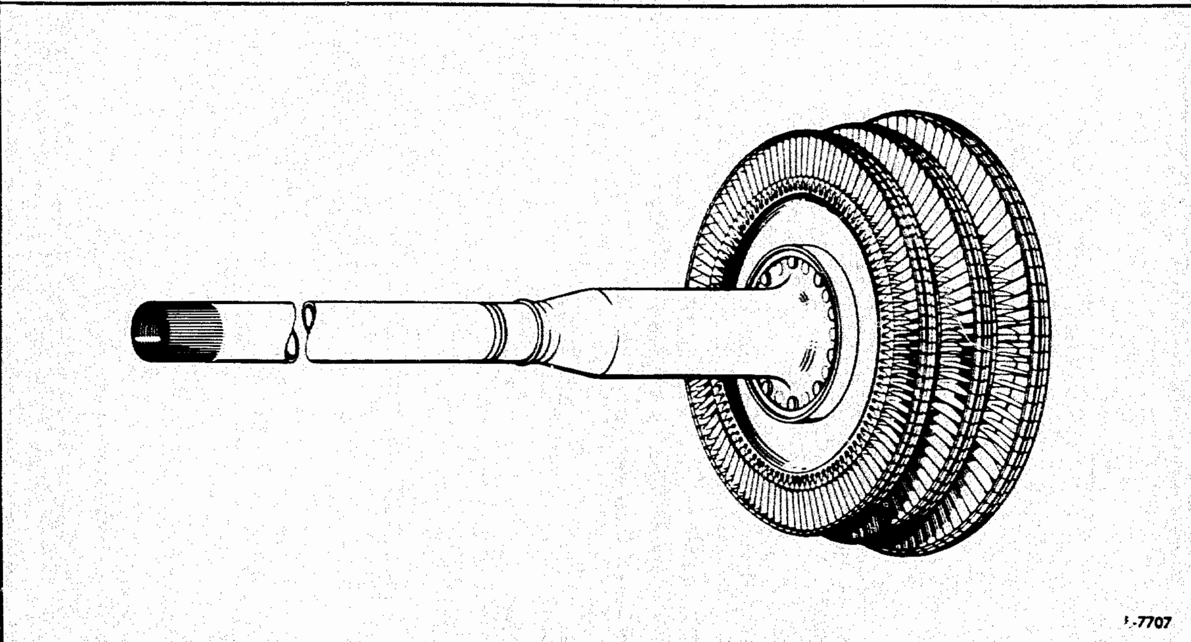
See Figure 31.

Three disks with turbine blades, a rear hub, a spacer, and a drive shaft make up the rotor. The second stage disk is bolted to the driveshaft and the rear hub. The third and fourth stage disks are held together and to the second stage disks by ten tierods.

Turbine Blades

See Figure 27.

The second stage turbine blades are cast from stainless steel. Third stage blades are cast from stainless steel, while fourth stage blades are forged from nickel alloy. They are assembled in the manner previously described under the Rear Compressor Drive Turbine Rotor - Turbine Blades. The second stage blades are larger in height than those of the first stage, the third stage blades are even larger, and the fourth stage blades are the largest. The reason for this is to match the blade size to the increase in volume of gas as it expands while passing through the turbine. There are 114 blades in the second stage disk and blade assembly, 108 blades in the third stage, and 80 blades in the fourth stage.



Front Compressor Drive Turbine Rotor
Figure 31

Turbine Disks

The second stage turbine disk is made from corrosion and heat resistant steel. The third and fourth stage disks are made from corrosion and heat resistant steel. They are spearated from each other by spacers and are attached to the front compressor drive turbine shaft and the turbine rear hub by tierods as mentioned above.

Front Compressor Drive Turbine Shaft

The front compressor drive turbine shaft is made from low chrome steel alloy. It is a long thin shaft as it must pass through the first stage turbine rotor shaft and must reach from the front of the second stage turbine disk to the rear hub of the front compressor. Its front end is supported inside the front compressor hub, its middle by a bearing inside the rear compressor turbine rotor shaft, and its rear end by the turbine assembly which in turn is supported by a bearing at the turbine rear hub.

The shaft is hollow and provides a passage for 9th stage cooling air which passes through holes in the rear hub to cool the rear bearing seals, oil pump and the rear face of the fourth stage turbine disk. Oil is also piped through the shaft to its middle bearing. The forward end of the shaft is externally splined and internally threaded. The shaft external splines mate with the internal splines on the front compressor rear hub, and the shaft internal threads mate with the external threads on the front compressor drive turbine coupling.

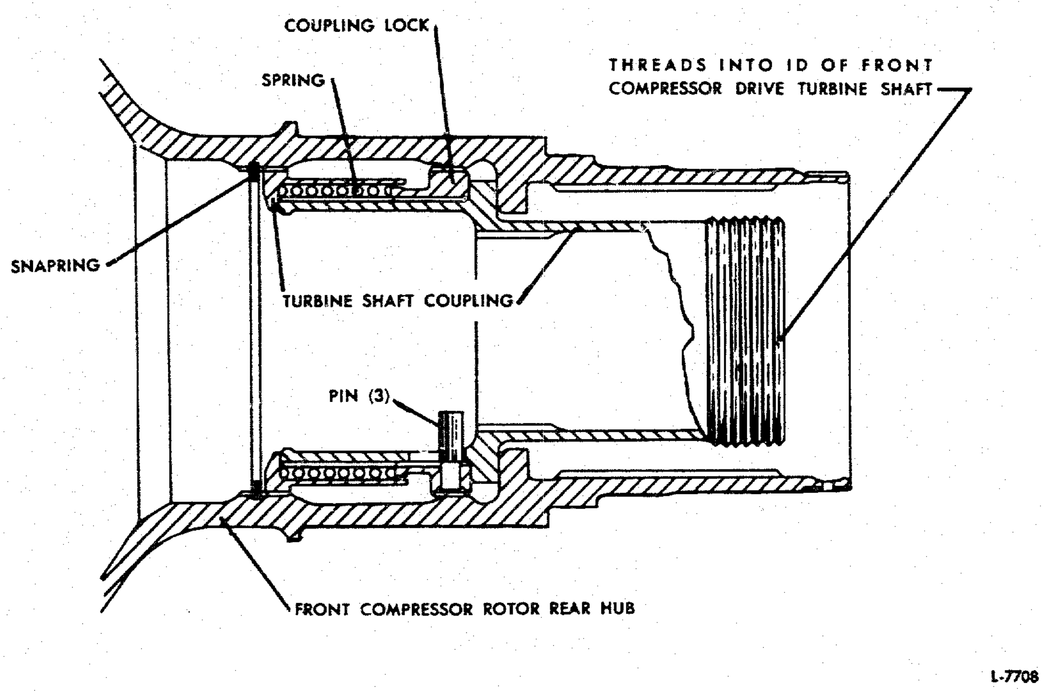
A spacer is used between the compressor rear hub shaft and the front edge of the drive shaft to position the shaft correctly.

Coupling

See Figure 32.

The coupling's external shoulder butts against an internal shoulder in the front compressor hub. The internal splines in the coupling are for the wrench. The coupling front end has external splines with three short slots. A ring having external and internal splines and three inward projecting pins, fit over the forward end of the coupling, the pins projecting through the slots. A compression spring is located just forward of the spline pinned ring and is held in place by an internal shoulder of a collar. The collar is held in the coupling by splines and a snapring. The spring keeps a rearward pressure on the ring which will lock the ring's external splines to the internal splines in the compressor hub. These splines are just forward of the shoulder and as long as the ring is locked, the coupling cannot be unscrewed.

In order to unscrew the coupling from the drive shaft, the ring must first be moved forward against the spring pressure until its external splines disengage the small internal spline that is inside of the compressor hub ahead of the internal shoulder. The pins that project through the slots in the coupling are used to move the ring forward. A special wrench is used that can pull the pins forward and then engage wrenching splines to turn the coupling.



Front Compressor Drive Turbine Coupling
Figure 32

Exhaust Section

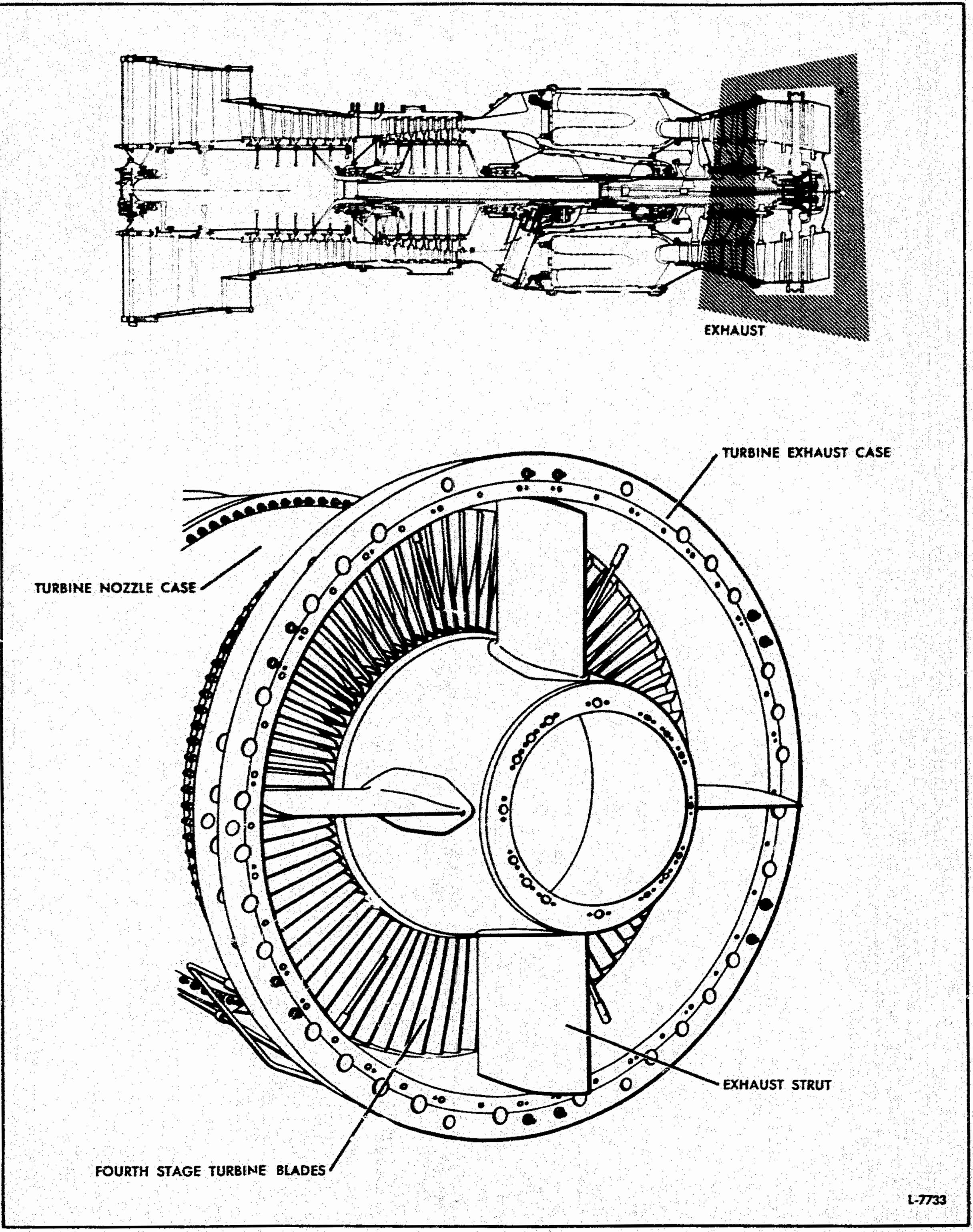
See Figure 33.

The exhaust section of the engine includes all items following the turbine except the tailpipe and other rearward attachments which are furnished by the airframe manufacturer.

Turbine Exhaust Case

See Figure 33.

The outer case is constructed of chrome-nickel steel. It bolts to the rear of the turbine case at its front flange and its rear flange bolts to the tailpipe. Two heavy external flanges near the center of the case are used for engine mounting.



Exhaust Section
Figure 33

ENGINE - DESCRIPTION AND OPERATION

The outer case supports all the parts used in the inner case. A few parts are mounted directly on the outer case. The fourth stage turbine outer seal is located in the front of the outer case, the flange of which is positioned between the rear flange of the turbine nozzle case and the forward flange on the exhaust case.

A turbine exhaust fairing assembly, consisting of an inner duct and four turbine exhaust struts, is positioned in the exhaust case. Four No. 6 Bearing support rods pass through the struts and through the holes in the outer case and are secured in strut supports between the engine mounting flanges mentioned above at the 12, 3, 6, and 9 o'clock positions. These rods are secured and positioned by a dual nut locking arrangement in the strut supports. At the inner end, the rods are bolted to lugs on the No. 6 Bearing housing. When assembled, the struts envelope the rods and the oil tubes (to be discussed) for streamlining. At the 3 o'clock position and to the rear of the support rod, the No. 6 Bearing pressure oil tube passes from outside the exhaust case to the No. 6 Bearing support. At the 6 o'clock position, the No. 6 Bearing scavenge oil tube is installed in the same manner.

A flange attached to the No. 6 Bearing support holds the sump adapter to which the No. 6 Bearing sump is attached. The entire sump area is enveloped by a heatshield. The fairing assembly area, internal to the struts, is also covered by a heatshield. An average pressure rake manifold is mounted around the case forward of the engine mounting flange. Just forward of the rear flange, the temperature thermocouples are installed. Attached to each are leads from a thermocouple harness which circles the case at this point.

No. 6 Bearing Support and Shields

The No. 6 Bearing seals buildup and No. 6 Bearing inner race and rollers are mounted on the rear hub. The outer race is held in a housing which also serves as the seals housing. This housing is attached to and is held by the No. 6 Bearing support. Four support rods from the outer case thread into the rear of the support. Attached to the rear of the support is the sump adapter to which the sump is bolted. The rear heatshield is bolted to the rear heatshield flange which is retained in the support by the adapter. Bolted to the front of the No. 6 Bearing support is the No. 6 Bearing air seal support. A knife-edge is riveted to its forward extremity to ride on a shoulder which is riveted to the rear hub thus forming a gas seal.

No. 6 Bearing Oil Sump

The sump contains the No. 6 Bearing oil scavenge pump which is driven by a pinion gear attached to the rear hub. Inserted through the pinion is the oil nozzle which provided lubrication for the No. 4 1/2 Bearing inside the turbine shaft. The sump bolts to the rear of the adapter and has a cover plate bolted to its rear side. "O" ring seals are used between the sump adapter and the support and between the sump and the rear cover. The rear heatshield is bolted to the front heatshield at external flanges. The two heatshields cover all components inside the inner duct. All the metal parts are steel.

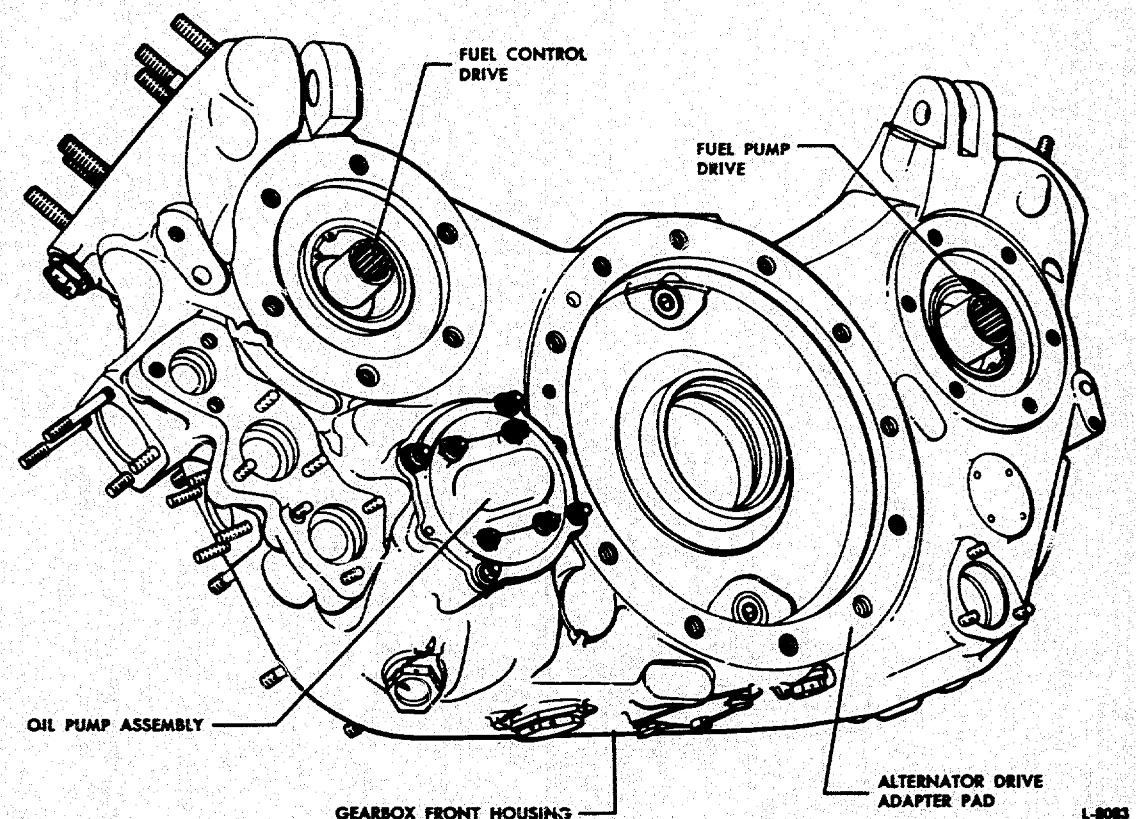
ENGINE - DESCRIPTION AND OPERATION

MAIN ACCESSORY SECTION.

Accessory Component Drive Gearbox Assembly

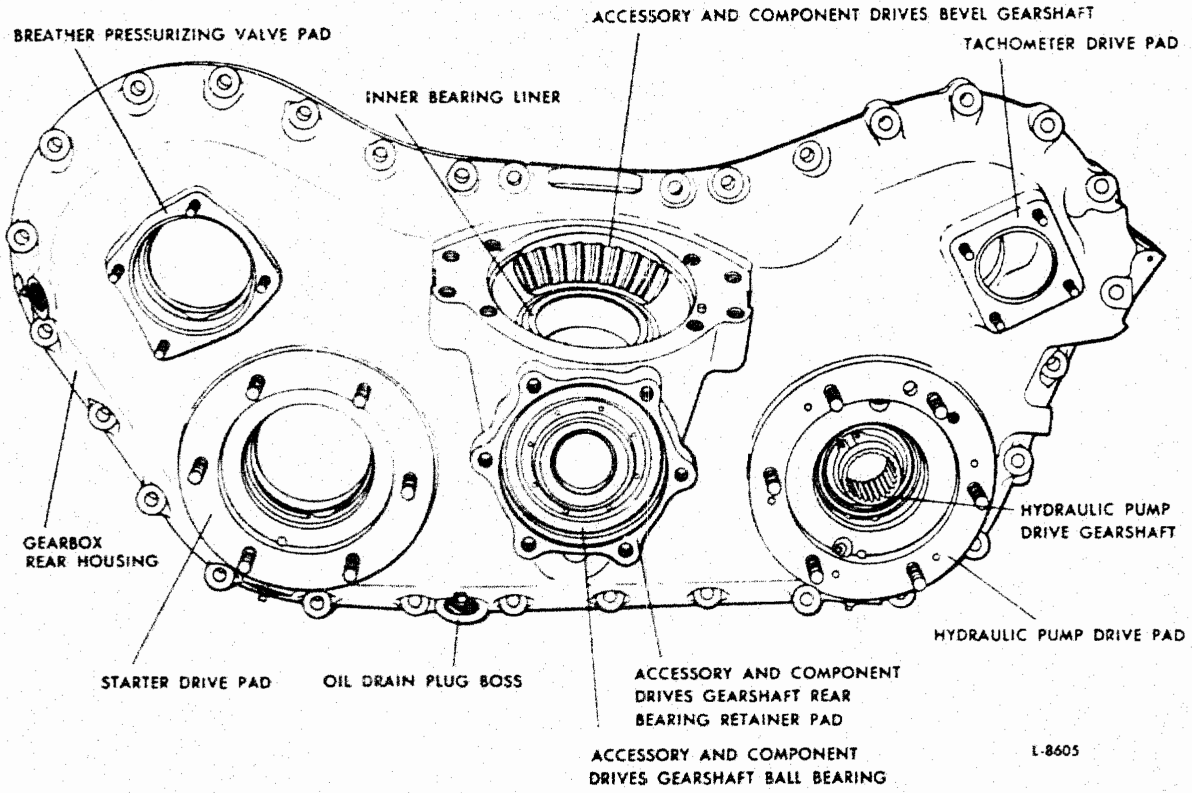
The accessory component drive gearbox consists of a front housing and a rear housing. See Figures 34 and 35. The gearbox assembly is mounted beneath the engine and secured to the diffuser case front flange. Power is supplied to the gearbox assembly from the rear compressor rotor shaft through an integral elbow on the rear housing. The main oil pump is located at the lower right front of the gearbox assembly.

The engine fuel control mounts to a six studded circular pad on the upper right front of the gearbox housing, and the fuel pump mounts on a similar pad on the upper left front. Gearing is provided to drive the fuel control, the fuel pump, high compressor tachometer, and a fluid pump drive. On the JT3D-1, D-3 and D-3B (Boeing), the JT3D-1-MC6, and JT3D-1-MC7 engines, a water pump drive is incorporated in the left side vertical drive. On the JT3D-1, D-3 and D-3B (Douglas), a fuel boost pump drive is incorporated in the right side vertical drive. The other vertical housings (right Boeing and left Douglas) are unused. Provisions are made for mounting a constant speed drive (Boeing) or with an adapter, a generator (Douglas) on the large alternator center front pad. At the left rear of the gearbox a six studded pad is provided for a starter. The starter rotates the high compressor rotor through gearing and shafts. A six studded fluid pump drive pad is positioned on an angle near the top on each side of the gearbox and another at the right rear of the gearbox.



Accessory Component Drive Gearbox Front Housing Assembly

Figure 34



Accessory Component Drive Gearbox Rear Housing Assembly
Figure 35

Accessory Component Drive Gearbox Front Housing Assembly

See Figure 36.

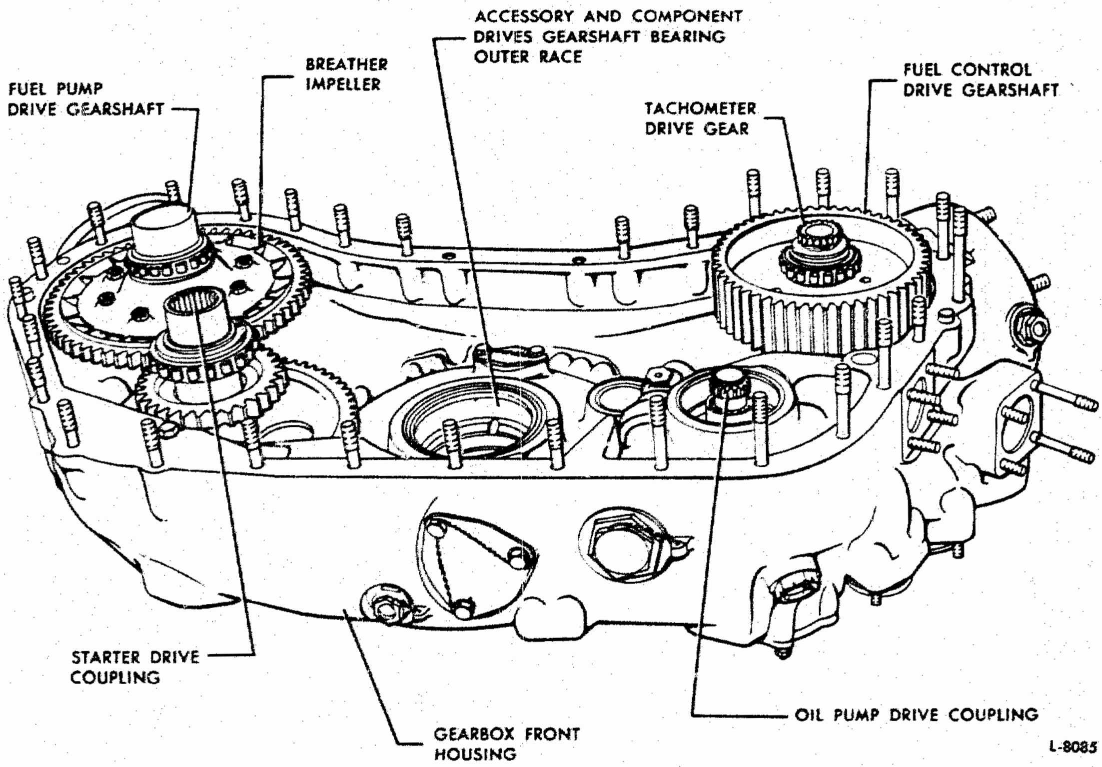
The oil pump assembly, the fuel control, fuel pump and starter drive shaftgears, and the tachometer drive gear are located in the front housing. The duplex oil pump is mounted at the lower right front of the front housing. The pump is composed of two sections. The rear section is the pressure section; while the front section scavenges the gearbox assembly. The pump is a positive displacement, gear type pump. The pressure pump section receives oil from the tank, pumps it through the strainer and to all main bearings of the engine. The scavenge pump section clears the gearbox of scavenge oil and sends it to the oil tank. The scavenge pump assembly is provided with an inlet strainer which is positioned upstream of the pump and located in the bottom of the accessory drives gearbox front housing. The right vertical fluid drive (if incorporated) is driven by a gear

bolted to the fuel control drive gear shaft and the left vertical fluid drive (if incorporated) is driven by a gear bolted to the fuel pump drive gear shaft. An oil impeller which is a centrifugal device used to separate oil from air is also attached to the fuel pump drive gear. Later configurations incorporate an oil pressure tube assembly connected to the oil pressure relief valve which supplies a continuous flow of oil to the fuel pump drive splines by means of a nozzle staked in the bearing bushing.

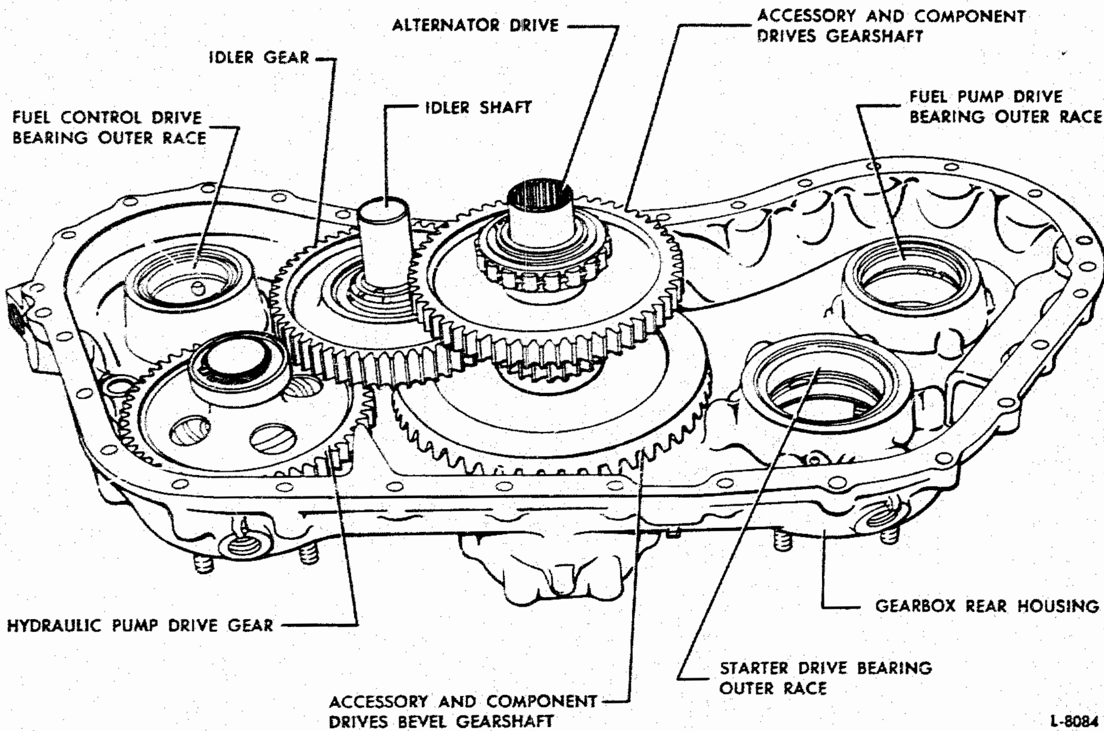
Accessory Component Drive Gearbox Rear Housing Assembly

See Figure 37.

The rear housing contains the main accessory drive and idler gears, the tachometer drive, and the rear bearings for the horizontal gear trains. Between the main accessory drive gear and the fuel control drive gear is the idler gear through which power is transmitted to the right side of the gearbox. Splined to the alternator drive shaftgear is the main accessory drive gear which mates with the angled accessory drive gear in the elbow section of the housing. The angled accessory drive gear transmits power from the high compressor to the gearbox. The alternator drive shaftgear transmits power to the left side of the gearbox assembly through the starter drive shaftgear and the fuel pump drive gear. The tachometer drive is run by a tachometer drive gear internally splined to the fuel control drive gear.



Accessory Component Drive Gearbox Front Housing and Gears
Figure 36



Accessory Component Drive Gearbox Rear Housing and Gears
Figure 37

Bearings

See Figure 38.

The bearings in the engine are of either the ball or roller type. Eight bearings are used on the principal rotating masses of the engine although in two instances, which we will discuss below, two bearings act as one. Twenty-five bearings are also used in fuel, oil, and accessory systems.

No. 1 Bearing

See Figure 39.

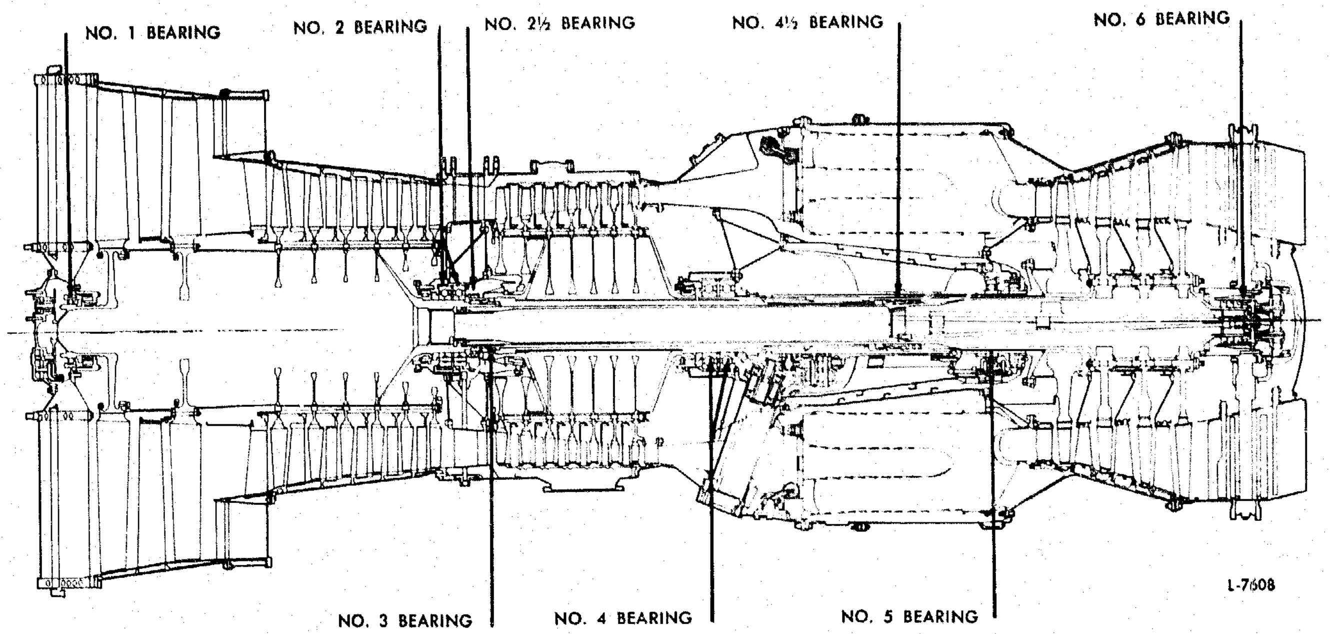
The No. 1 bearing is of the roller type and is located at the front hub of the front compressor. Its outer race is held in a housing by means of a spanner nut and nut locking rivet. The housing is supported by the No. 1 bearing front support and No. 1 bearing seal and support assembly at the center of the inlet guide vane circle. Its inner race has a pinch fit on the front compressor front hub and is further held in place by a spacer, a seal plate, a spanner nut and a nut locking rivet. The inner race is larger than its rollers to allow for engine dimension changes with temperature. An oil seal assembly is used on the rear side of the bearing.

No. 2 Bearing

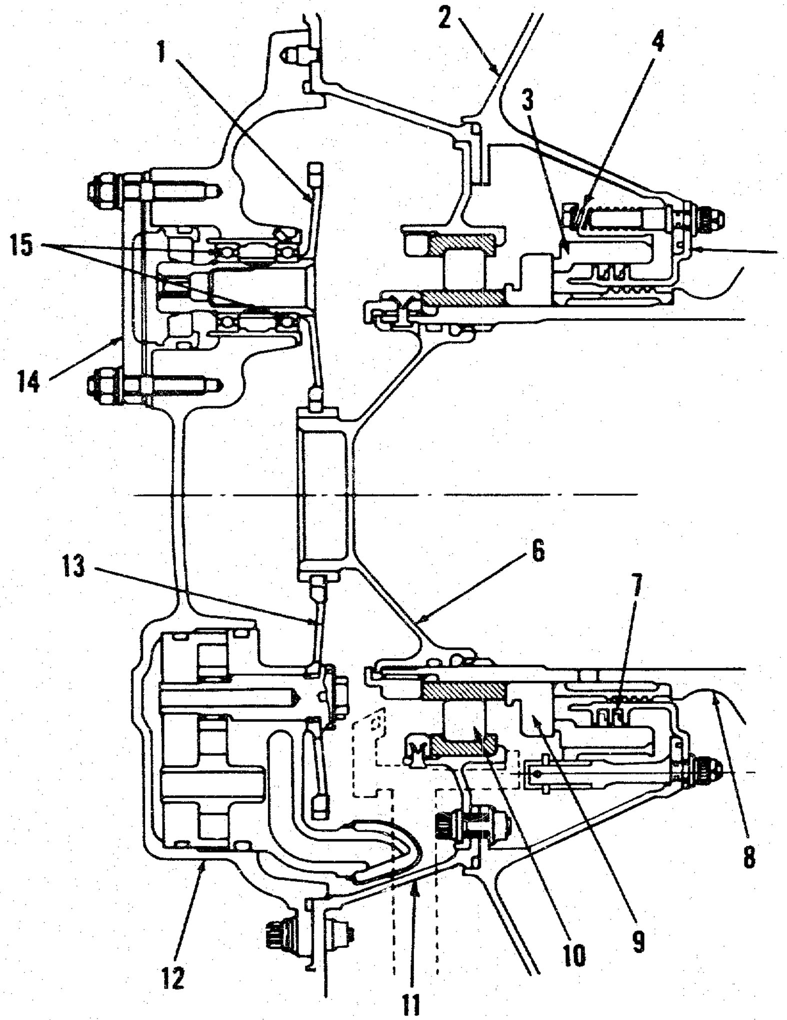
See Figure 40.

The No. 2 bearing is of the ball type. It is a duplex bearing with two bearings acting as one. They are a matched pair. Their outer races are carried in a steel housing. This housing is supported by three steel pieces that make up the bearing support at the rear compressor inlet vanes. These races are separated by an oil baffle and are held in place by an external shoulder in the housing and a spanner nut and tabwasher. The inner races of both these are split to aid installation. They are a pinch fit on the rear compressor rear hub and are held in place by a hub shoulder, seal plate, oil baffle, and retaining nut. An oil seal assembly is used on the front side of the bearing. Bearings No. 1 and No. 2 are the front compressor rotor supports.

In order to reduce absorption of heat by engine oil, heatshielding and thermal blanket insulation is provided for the No. 2 bearing compartment on the JT3D-3. Bolts that secure the compressor intermediate front bearing housing to the rear face of the front bearing inner support also secure the compressor intermediate front bearing front heatshield to the front face of the support.



Main Bearing Numbering
Figure 38



1. Tachometer Drive Gear
2. No. 1 Bearing Rear Support
3. No. 1 Bearing Seal
4. No. 1 Bearing Seal Spring
5. No. 1 Bearing Seal Support
6. Front Accessory Drive Main Spur Gear
7. No. 1 Bearing Seal Rings
8. No. 1 Hub
9. No. 1 Bearing Seal Spacer
10. No. 1 Bearing
11. No. 1 Bearing Front Support
12. Front Accessory Drive Front Support
13. Scavenge Pump Drive Gear
14. Accessory Drive Cover
15. Tachometer Drive Gear Bearings

No. 1 Bearing and No. 1 Bearing Seal Assembly

Figure 39

ENGINE - DESCRIPTION AND OPERATION

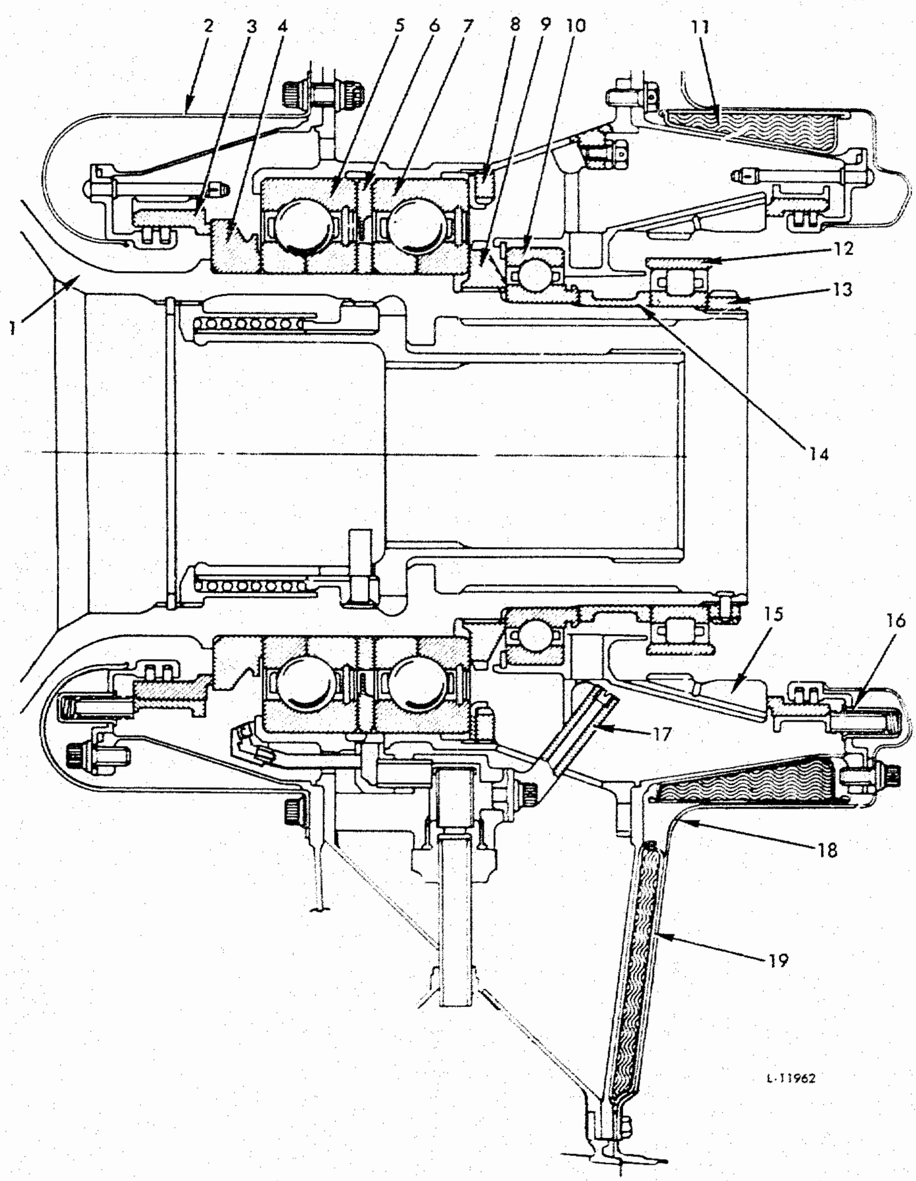
The compressor intermediate rear bearing heatshield consists of a front and rear heatshield both of which are secured together and in turn are secured as a unit to the rear face of the compressor intermediate bearing rear support.

The thermal blanket insulation is contained within the heatshield.

No. 2 1/2 Bearing

See Figure 40.

The No. 2 1/2 Bearing is a small single row ball bearing and serves as part of the support for the No. 2 1/2 Bearing housing. This housing is part of the seal system for the aft end of No. 2, 2 1/2, and No. 3 Bearings. The outer race is held in the No. 2 1/2 Bearing housing by a snapring. Its inner race is on the front compressor rear hub and is held in place between No. 2 Bearing inner race retaining nut and a spacer. This spacer in turn is held in place by the No. 3 Bearing inner race.



1. No. 2 Hub
2. Front Bearing (No. 2) Front Heatshield
3. No. 2 Bearing Seal Assembly
4. No. 2 Bearing Seal Plate
5. No. 2 Bearing (Front)
6. No. 2 Bearing Oil Baffle
7. No. 2 Bearing (Rear)
8. No. 2 Bearing Outer Race Retaining Nut
9. No. 2 Bearing Inner Race Retaining Nut
10. No. 2 1/2 Bearing
11. Heatshield Insulation Blankets (2)
12. No. 3 Bearing
13. No. 3 Bearing Inner Race Retaining Nut
14. No. 3 Bearing Spacer
15. No. 2 1/2 Bearing Housing
16. No. 3 Bearing Seal Assembly
17. Oil Pressure Manifold
18. No. 2 Rear Bearing Heatshield
19. No. 2 Rear Bearing Front Heatshield

No. 2, No. 2 1/2, and No. 3 Bearings and Seals Buildup

Figure 40

No. 3 Bearing

See Figure 40.

The No. 3 Bearing is of the roller type and forms the front hub support for the rear compressor. Its outer race is a force fit into the inside diameter of the rear compressor front hub. A shoulder and a snapring hold the race in place. The inner race and rollers are shrunk onto the OD of the front compressor rear hub. A retaining nut, secured by a rivet, jams this inner race against the spacer just in the rear of the No. 2 1/2 Bearing inner race.

No. 4 Bearing

See Figure 41.

The No. 4 Bearing is of the ball type. It is a duplex bearing with two bearings acting as one. It forms the support for the rear hub of the rear compressor. The outer races are mounted in a housing which is supported inside of the engine diffuser case. They are held in place by a shoulder and a spacer under the diffuser case bolt ring. There is an oil baffle between the outer races. The inner races are the split type, a pinch fit to the OD of the rear compressor rear hub. These races are positioned by a shoulder on the shaft, a seal plate, an oil baffle between the races, a spacer ring, a bevel gear and a retaining nut with a lock and snapring. There is an oil seal housing on the forward side of this bearing.

To reduce swirl and heat rejection a compressor rear bearing oil scavenge baffle assembly is provided in the JT3D-3. The baffle assembly is mounted on the longer studs of the compressor rear bearing support.

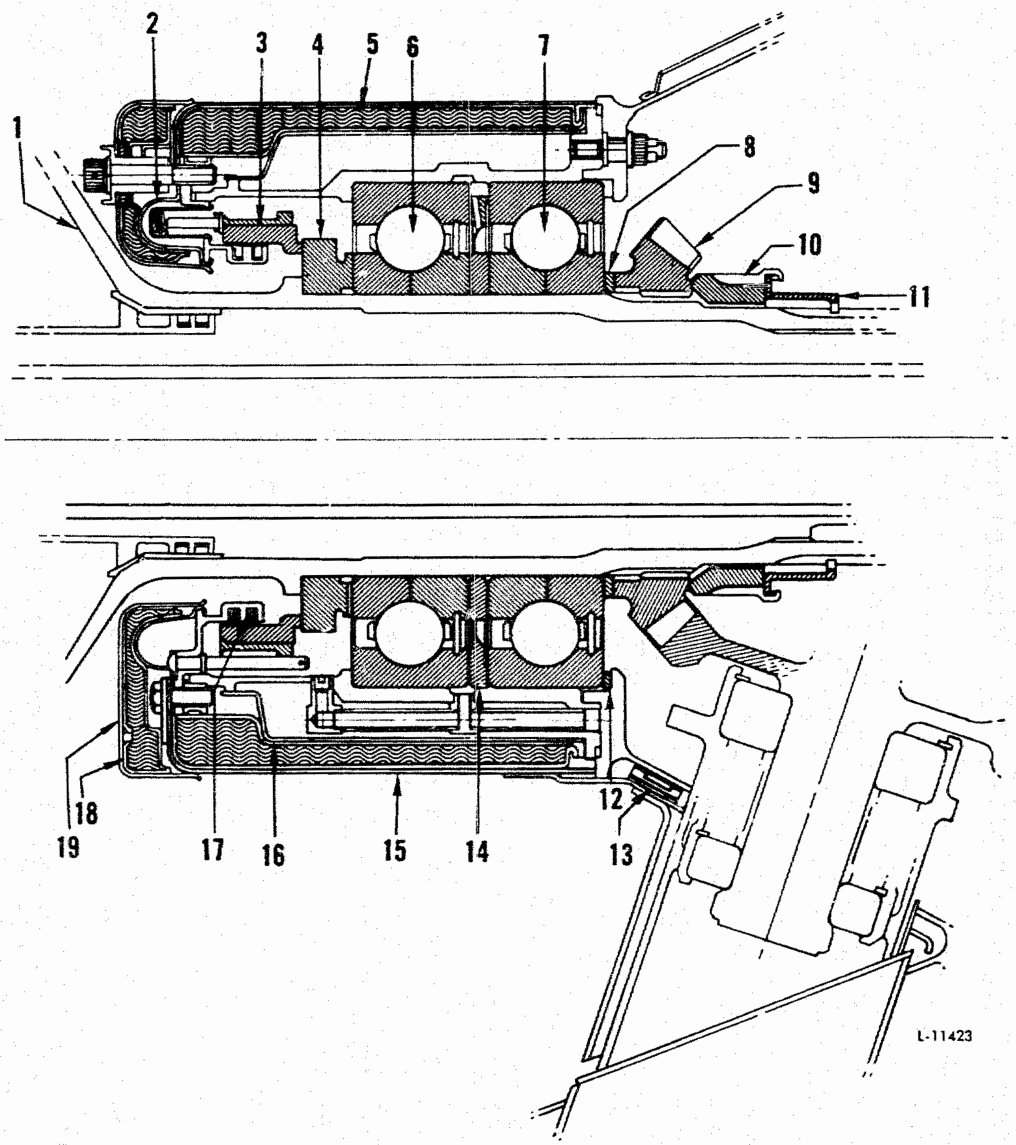
To reduce absorption of heat by the engine oil, heatshielding and thermal blanket insulation is provided for the No. 4 Bearing compartment. The compressor rear bearing heatshield assembly consists of several individual heatshields welded together. The complete unit is bolted to the compressor rear bearing housing and extends over the bearing housing, the breather tube, the oil pressure and scavenge tubes and along the tower shaft.

The thermal blanket insulation is contained within the heatshield.

No. 4 1/2 Bearing

See Figure 42.

The No. 4 1/2 Bearing is a small roller bearing which is located between the front and rear compressor turbine drive shafts to minimize the whip of the long (front) shaft. Its outer race is in the ID of the rear compressor drive turbine shaft. The race is held between a spacer on the shoulder on the ID of the shaft

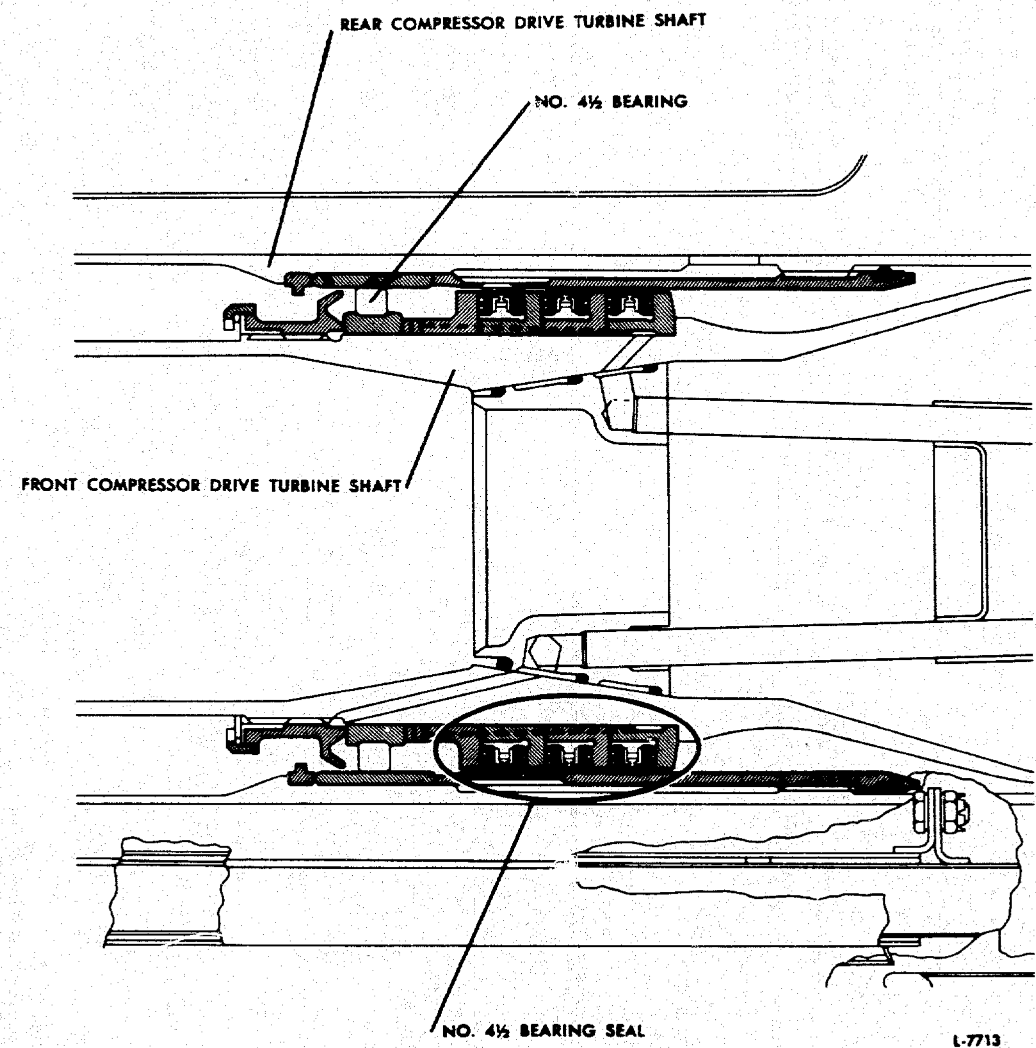


1. No. 4 Hub
2. No. 4 Bearing Seal Housing Assembly
3. No. 4 Bearing Carbon Seal Assembly
4. No. 4 Bearing Seal Plate
5. No. 4 Bearing Inner Thermal Blanket Heatshield (2)
6. No. 4 Bearing (Front)
7. No. 4 Bearing (Rear)
8. No. 4 Bearing Inner Race Spacer (Classified)
9. Accessory Drive Gear
10. Accessory Drive Gear Retaining Nut
11. Accessory Drive Gear Retaining Nut Lock
12. No. 4 Bearing Outer Race Spacer (Classified)
13. No. 4 Bearing Rear Heatshield (Not for MC-6)
14. No. 4 Bearing Oil Baffle Assembly
15. No. 4 Bearing Center Heatshield
16. No. 4 Bearing Housing
17. No. 4 Bearing Seal Assembly Oil Seal Rings
18. No. 4 Bearing Thermal Blanket Heatshield
19. No. 4 Bearing Front Heatshield

No. 4 Bearing and Seal Buildup

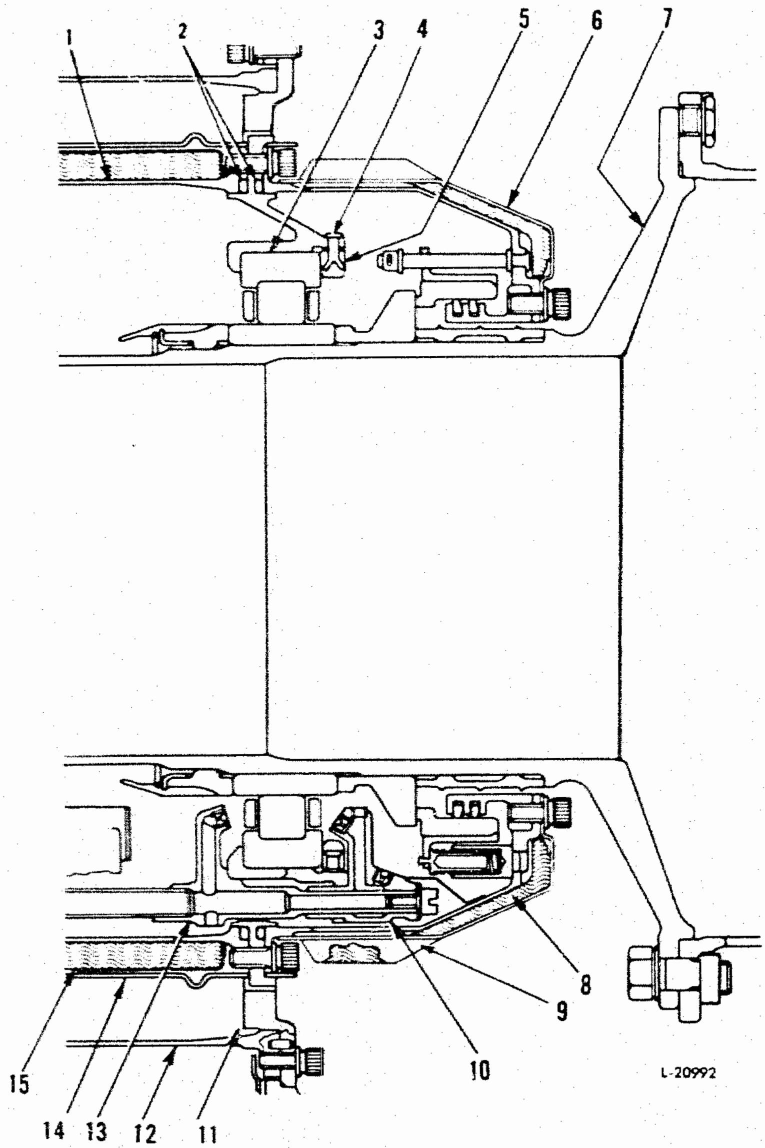
Figure 41

and the turbine shafts bearing seals liner. The liner is torqued to specification. The bearing inner race and cage are shrunk onto the front compressor drive turbine shaft. This race is held on the shaft by a shoulder on the shaft, the bearing seal assembly, a spacer and a retaining nut, a tabwasher, and a snapring assembly.



No. 4 1/2 Bearing and Seals Buildup (JT3D-1, D-3, D-3B,MC7)

Figure 42



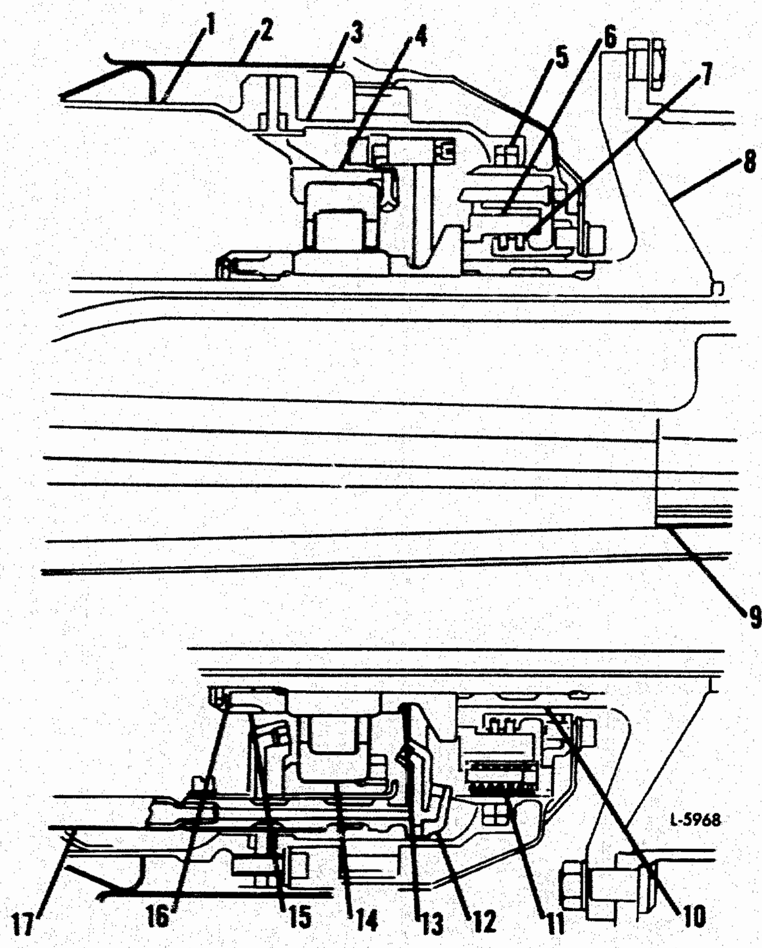
1. No. 5 Bearing Support
2. Gaskets
3. No. 5 Bearing
4. Rivet
5. Outer Race Retaining Nut
6. No. 5 Bearing Seal Assembly
7. Turbine Rotor Shaft (Typical)
8. Turbine Front Bearing Heatshield (2)
9. Turbine Front Bearing Heatshield Assembly
10. No. 5 Bearing Oil Pressure Manifold
11. No. 5 Bearing Housing Support
12. Combustion Chamber Case
13. No. 5 Bearing Oil Pressure Tube
14. Heatshield
15. Turbine Front Bearing Front Heatshield

No. 5 Bearing And Bearing Seal Buildup (JT3D-1, D-3, D-3B And MC-7)

No. 5 Bearing

See Figures 43 and 44.

The No. 5 Bearing is a roller type bearing, located just forward of the rear compressor turbine. It forms the support for the rear compressor drive turbine shaft. The bearing outer race housing and its seal housing are carried by the turbine front bearing support and the nozzle case and outlet duct assembly. The outer race carries the bearing cage and rollers. It is held in its housing by a retaining nut which is torqued and riveted. The bearing inner race is shrunk onto the outside diameter of the rear compressor turbine shaft. This race is slightly wide to allow for engine temperature growth. The race is held in place by a shaft shoulder, air seal spacer, seal plate, retaining nut and a retaining nut tablock-snap ring assembly.



1 NO. 5 BEARING SUPPORT
2 NO. 5 BEARING SEAL HOUSING
3 NO. 5 BEARING SEAL SUPPORT
4 NO. 5 BEARING SUPPORT
5 RING OIL SEALS
6 NO. 5 BEARING SEAL
7 RING OIL SEALS
8 TURBINE ROTOR HUB
9 NO. 4½ BEARING OIL SHIELD
10 NO. 5 BEARING SPACER
11 NO. 5 BEARING SEAL SPRING
12 NO. 5 BEARING OIL METERING PLUG
13 NO. 5 BEARING SPACER
14 NO. 5 BEARING
15 NO. 5 BEARING NUT
16 NO. 5 BEARING NUT TABLOCK
17 NO. 5 BEARING OIL PRESSURE TUBE

No. 5 Bearing and Seal Buildup (JT3D-1-MC6)

Figure 44

No. 6 Bearing

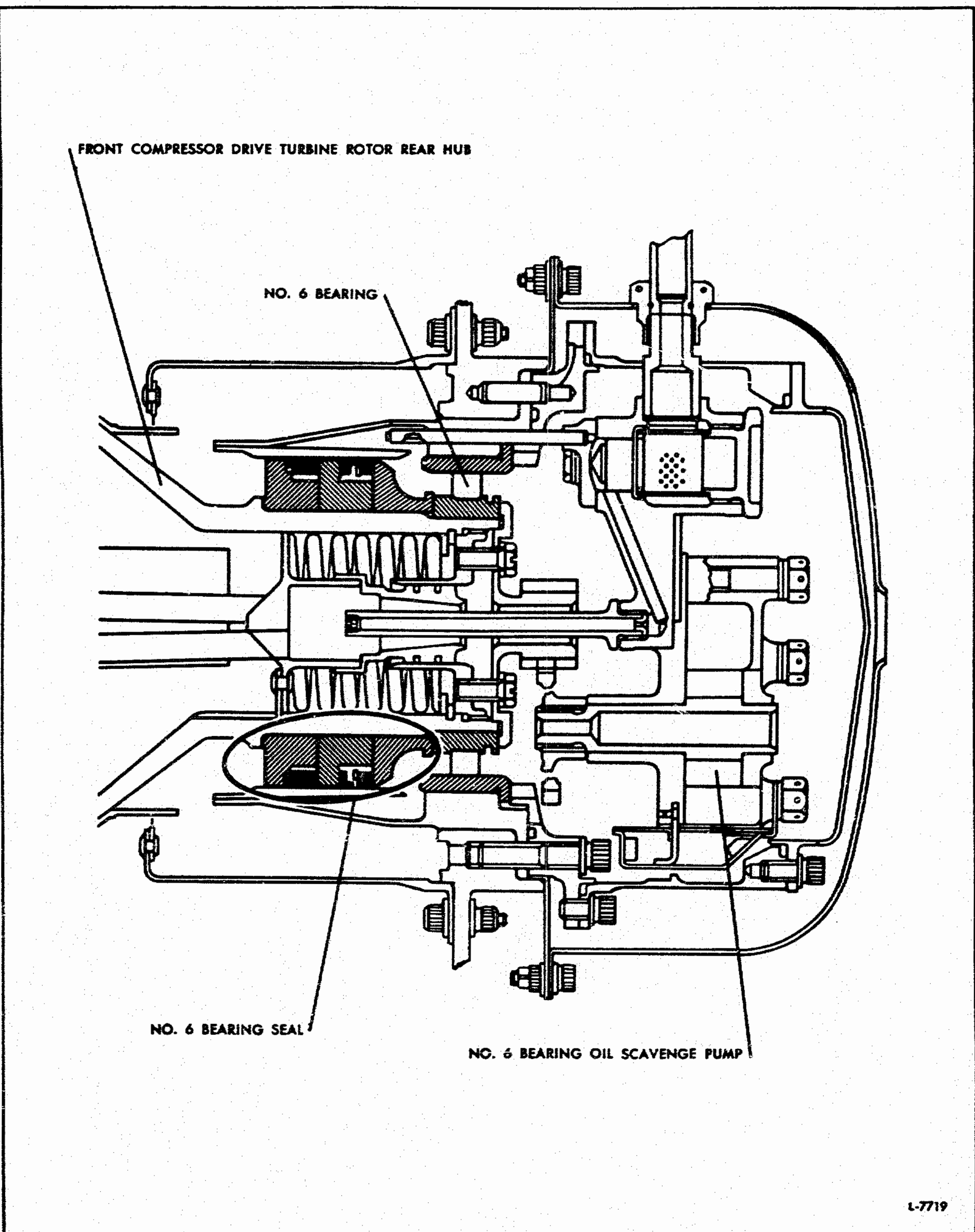
See Figures 45 and 46.

The No. 6 Bearing is a roller type bearing which forms the support for the compressor turbine rear hub. The outer race is held in a housing which is bolted to the assembly. The support assembly is held by support rods which carry the load to the structure of the turbine exhaust case. The inner race, which holds the roller and cage, has a force fit on the front compressor drive turbine rear hub. The inner râce is located and held fast by the hub shoulder, two seal spacers, a seal plate, and the rear oil scavenge pump pinion flange. This flange is in turn bolted to a carrier sleeve which is threaded into the hub shaft.

Miscellaneous Bearings

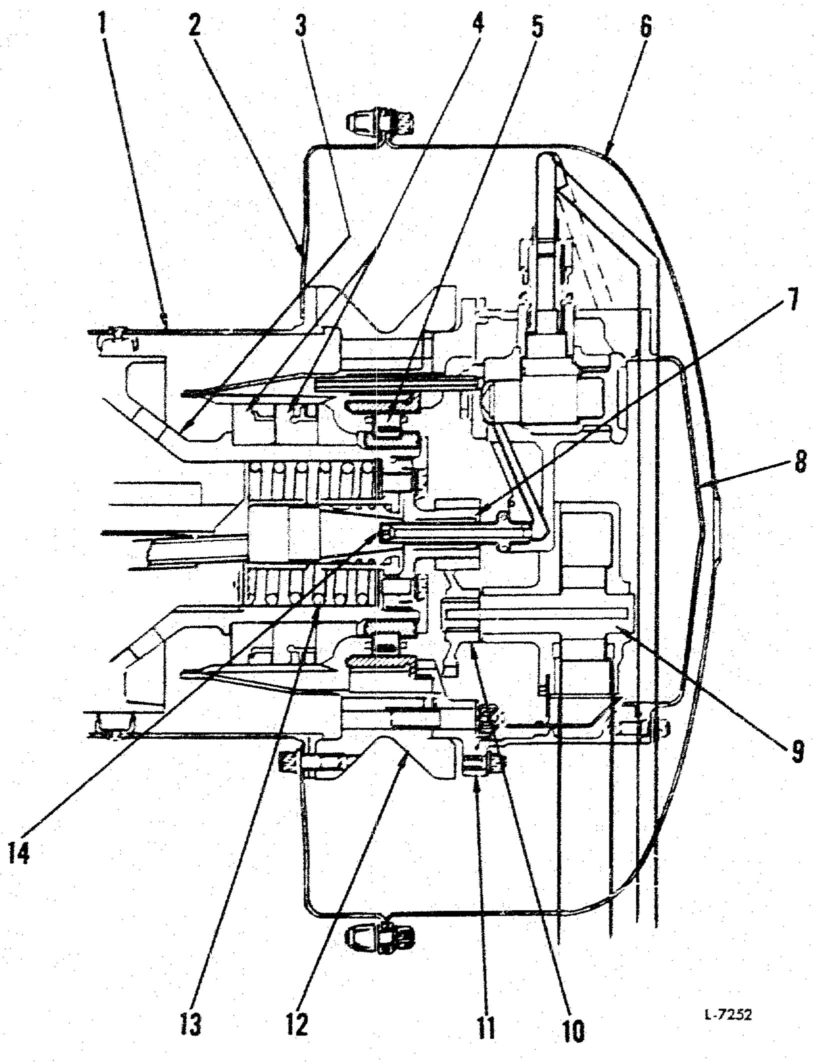
Listed below are the locations, quantity, and type of bearing used in addition to the main bearings discussed above.

Where Used	Type	Quantity	General Location
Tachometer Drive Shaftgear	Ball	2	Front Accessory
Scavenge Pump Internal Shaftgear	Ball	2	No. 4 & No. 5 Bearing Oil Pump Area
Main Accessory Component Drives Shaftgear	Ball Roller	1 1	Diffuser Case Diffuser Case
Hydraulic Pump Shaftgear	Ball Roller	1 1	Main Accessory Main Accessory
Hydraulic Pump Shaftgear (Vertical right-if used)	Ball Roller	1 1	Main Accessory Main Accessory
Fuel Control Shaftgear	Ball Roller	1 1	Main Accessory Main Accessory
Tachometer Drive Shaftgear	Ball	2	Main Accessory
Idler Gear	Roller	1	Main Accessory
Accessory Drive Gear (bevel)	Ball Roller	1 1	Main Accessory Main Accessory
Accessory Drive Shaftgear	Ball Roller	1 1	Main Accessory Main Accessory
Starter Drive Shaftgear	Ball Roller	1 1	Main Accessory Main Accessory
Fuel Pump Shaftgear	Ball Roller	1 1	Main Accessory Main Accessory
Hydraulic Pump Shaftgear (Vertical left-if used)	Ball Roller	1 1	Main Accessory Main Accessory



No. 6 Bearing and Seal Buildup
(JT3D-1, JT3D-1-MC7, JT3D-3, and JT3D-3B)

Figure 45



1 NO. 6 BEARING GAS SEAL
2 NO. 6 BEARING FRONT HEATSHIELD
3 TURBINE ROTOR HUB
4 NO. 6 BEARING OIL SEALS
5 NO. 6 BEARING
6 NO. 6 BEARING REAR HEATSHIELD
7 NO. 4½ BEARING OIL NOZZLE
8 NO. 6 BEARING OIL COVER
9 NO. 6 BEARING OIL SUCTION PUMP
10 NO. 6 BEARING PUMP DRIVE GEAR
11 NO. 6 BEARING SUMP ADAPTER
12 NO. 6 BEARING SUPPORT
13 NO. 4½ BEARING SHIELD SPRING
14 NO. 4½ BEARING OIL NOZZLE

No. 6 Bearing and Seal Buildup
(JT3D-1-MC6)

Figure 46

Oil Seals

Carbon face seals are used at starter and alternator drives; synthetic rubber lip seals are used at all other accessory drive locations. See Figure 46A. "O" ring seals are used between most non-moving parts where sealing is necessary and are also used to prevent fuel leakage into a bearing.

Oil sealing is very important in a jet engine because any wetting of the blades or vanes by oil vapor will encourage the accumulation of dust and dirt. A dirty blade or vane represents high friction to air flow, thus decreasing engine efficiency. This will result in a noticeable decrease in thrust or increase in fuel consumption.

The main engine seals are found in three configurations. The seals behind No. 1 Bearing, ahead of No. 2 Bearing, behind No. 3 Bearing, ahead of No. 4 Bearing, and behind No. 5 Bearing are all the same type, differing only in minor details. These seals are both spring loaded and air pressurized. The seal behind No. 4 1/2 Bearing obtains pressure from wedging action of spring washer between the seals. The seal in front of the No. 6 Bearing is a double unit, one seal being pressurized, the other seal being spring loaded.

Pressurized Spring Loaded Seal Assembly

The seal support carries two cast iron rings in grooves around its OD. A carbon seal, with its metal shield around it, slips over these rings. The flange on the metal shield is loosely held to the seal support by lockpins, stops, and cotter keys. This flange also rides on guide pins and against springs. The guide pins are held fast to the seal support and the springs are around the guide pins. These springs push the carbon seal and its shield away from the seal support against the lockpin stops. When the seal assembly is bolted into place in the engine the edge of the carbon seal will press against the chrome plated steel seal plate. The seal plate is held fast to the rotating shaft. The seal assembly is bolted to the bearing support.

No. 1 Seal

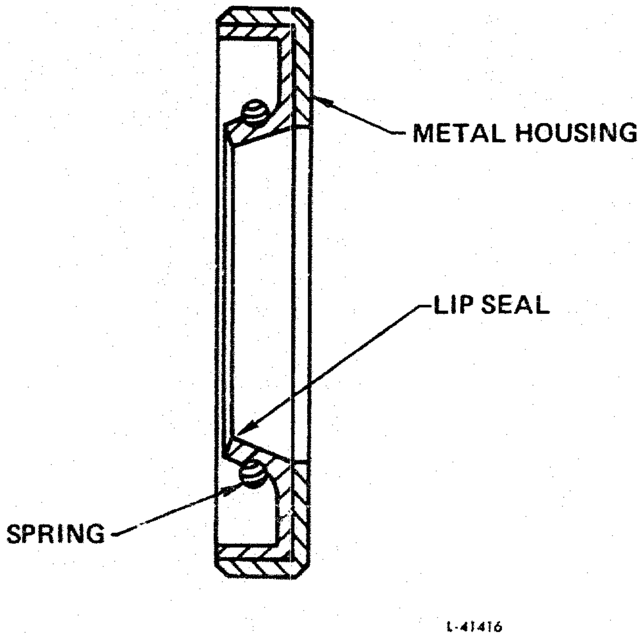
See Figure 39.

This seal support is bolted to the No. 1 Bearing support. Ninth stage air, at approximately 50 psi, is used to pressurize this seal. The air reaches the seal through a hole in the front hub of the front compressor. Air pressure is introduced in the space formed by the seal plate, the carbon seal, the seal rings and seal support assembly, and the hub spacer. Should there be any leakage between the seal plate face and the edge of the carbon seal, or seal and rings, the air flow will be toward the rear of the No. 1 Bearing. This will prevent oil from this bearing from entering the compressor.

No. 2 Seal

See Figure 40.

This seal support is bolted to the No. 2 Bearing front support. The seal plate



Synthetic Rubber Lip - Type Seal
Figure 46A

is on the rear hub of the front compressor. Ninth stage air, which surrounds the seal housing, pressurizes the seal. Operation is the same as described for No. 1 Bearing seal.

No. 3 Seal

See Figure 40.

The No. 2 Bearing rear support carries this seal's support. A heatshield is bolted to the rear of the seal support. The seal is pressurized by twelfth stage air which surrounds the housing. The seal plate is formed by the rear face of the compressor intermediate rear bearing housing.

No. 4 Seal

See Figure 41.

The diffuser section internal structure supports the No. 4 Bearing housing which in turn holds this seal support. The seal face plate is on the rear hub of the rear compressor. A cover is bolted to the front face of the support. The seal is pressurized by 16th stage air, which surrounds the seal support and bearing housing. Air pressure is about 150 psi.

No. 5 Seal

See Figures 43 and 44.

This seal assembly is mounted on the No. 5 Bearing support. Since it is necessary to use a heatshield in this location, there are some construction changes over those discussed above. The seal rings are carried on a separate housing which is bolted into a deep seal housing. The seal housing carries the lockpins, guides and springs. The carbon seal, with its metal shield is attached to these in the conventional manner. A separate seal support is used in this system. The support has internal oil seal rings backed by expander rings. This support is carried on the same bolt circle that carries the No. 5 Bearing support. This inner support is used to make the seal housing more rigid. A heatshield bolts to the rear end of the seal housing. Sixteenth stage air pressurizes this seal.

No. 6 Seal

See Figures 45 and 46.

The construction of this seal is entirely different from those discussed above. The assembly is made up of two carbon seals, two spacers, a seal plate, a spring washer, and a spring retaining nut. The seal system rotates with the turbine rotor hub inside of the turbine rear shaft gas seal support. This support is bolted to the No. 6 Bearing support. The forward carbon seal is pressurized by 9th stage air. This air is fed to the outside and forward faces of the carbon seal ring through a passage from inside of the hollow front compressor turbine shaft. The rear carbon seal is forced rearward against the seal plate by a

spring washer. This washer is held in place by a retaining ring. Sealing action is outward against the turbine rear shaft gas seal support, and rearward against the spacer and face plate.

No. 4 1/2 Seal

See Figure 42.

The No. 4 1/2 Bearing Seals Assembly is located between the front compressor drive and rear compressor drive shafts just to the rear of the 4 1/2 bearing. The seal keeps oil from the No. 4 1/2 bearing from traveling rearward and seals compressor discharge cooling air from the No. 4 1/2 bearing area. This seal consists of four spacers, six carbon graphite seals, six thrust rings and three spring washers mounted on the front compressor drive turbine shaft and is contained radially with a seals liner mounted in the rear compressor drive shaft. Radial force is provided by the diametrical spring pressure of the carbons, centrifugal force of the carbons and a radial pressure differential which locks the seals liner so that the seals turn with the rear compressor drive shaft. Lateral force of the seals against the seal plates is provided by the spring washers which exert pressure forward and aft through the thrust rings with the forward force augmented by a differential pressure. Sealing therefore, is provided by the diametrical spring pressure of the carbons, the centrifugal force of the carbons and a radially and lateral acting pressure differential. The seals and spacers are cooled by pressure oil from the No. 6 bearing area furnished by the tubes and heatshield assembly. The oil is discharged to a tapered space between the rear two of three seals. Drilled holes through the shaft allows the oil to flow to a radial slot on the ID of the rearmost spacer. The four spacers have eight equally spaced forward tapered slots on their internal diameter forming oil channels for the cooling oil mentioned above. An alignment pin positions the spacers and turbine shaft correctly. The No. 4 1/2 bearing inner race and seal spacers are held on the shaft by a bearing retaining nut.

Auxiliary Drive Seals

See Figure 47.

There are seven of these seals in the engine. One is in the front accessory front support and six in the main gearbox assembly. Carbon face seals are used at starter alternator drives; synthetic rubber lip seals are used at all other accessory drive locations. At most locations seals and seal housings are retained by snaprings. There is an "O" seal ring between each housing and the case.

Lubrication System

General

The lubrication system is of a high pressure design consisting of a pressure system, scavenge system, and a breather system. The pressure system supplies oil to the main engine bearings and to the accessory drives. The scavenge system scavenges the bearing compartments and accessory drives. The breather system interconnects the bearing compartments. The engine oil system is shown schematically in Figure 48.

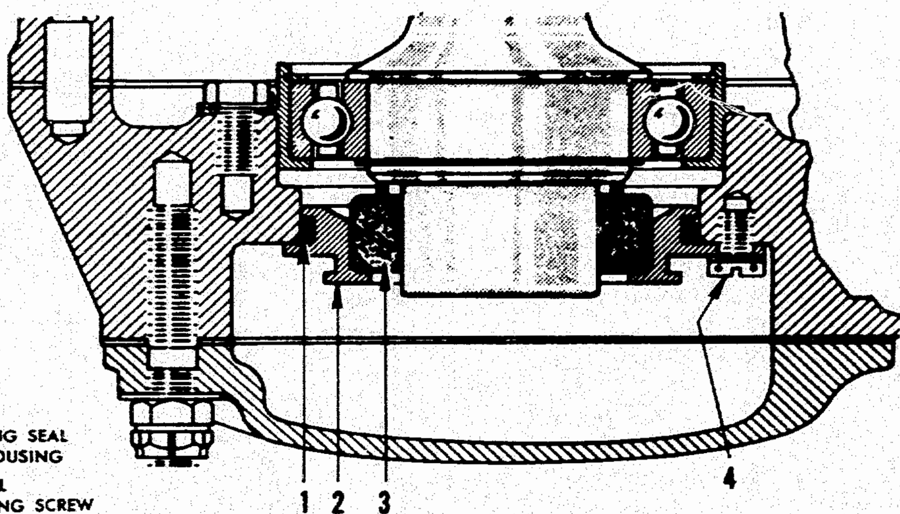
The engine is lubricated by a synthetic chemical base oil which must conform to PWA Specification 521. The system circulates seventy to eighty pounds of oil per minute. Pressure is 35 psi at engine idle and 40 - 60 psi maximum at operating speeds.

The lubricant changes its viscosity only slightly over a wide temperature range, thus engine warm-up time is very short. It is toxic, will attack most paints, and will soften both natural and synthetic rubber seals. It will cake at 450°F (232°C). It weighs 7.7 pounds per gallon at 60°F (16°C).

Pressure System

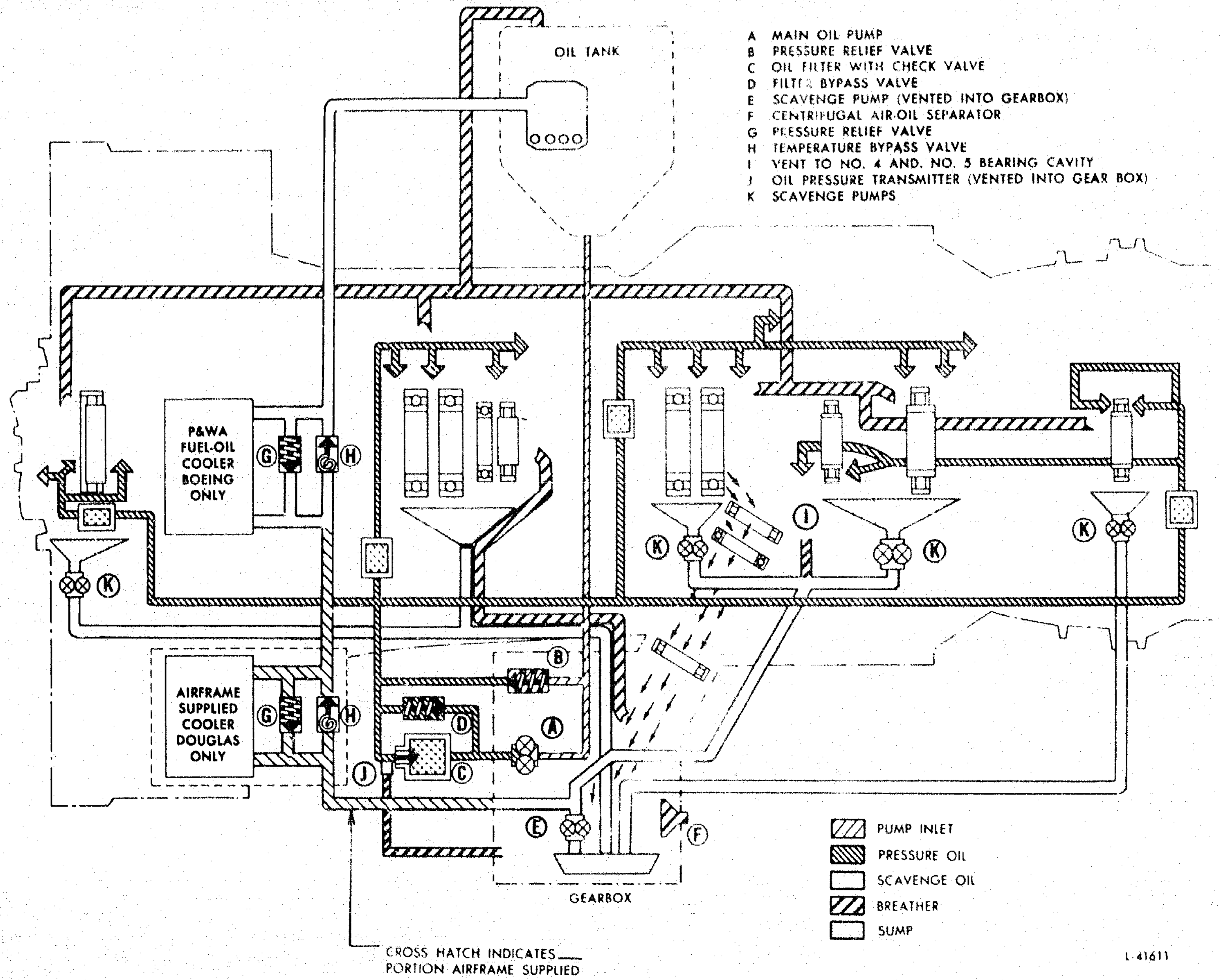
General

This system consists of a pressure pump, a pressure relief valve assembly, an oil strainer, an oil pressure (by-pass) valve, strainers, external tubing, internal passages and jets.



Typical Face Type Oil Seal

Figure 47



Lubrication System Schematic
Figure 48

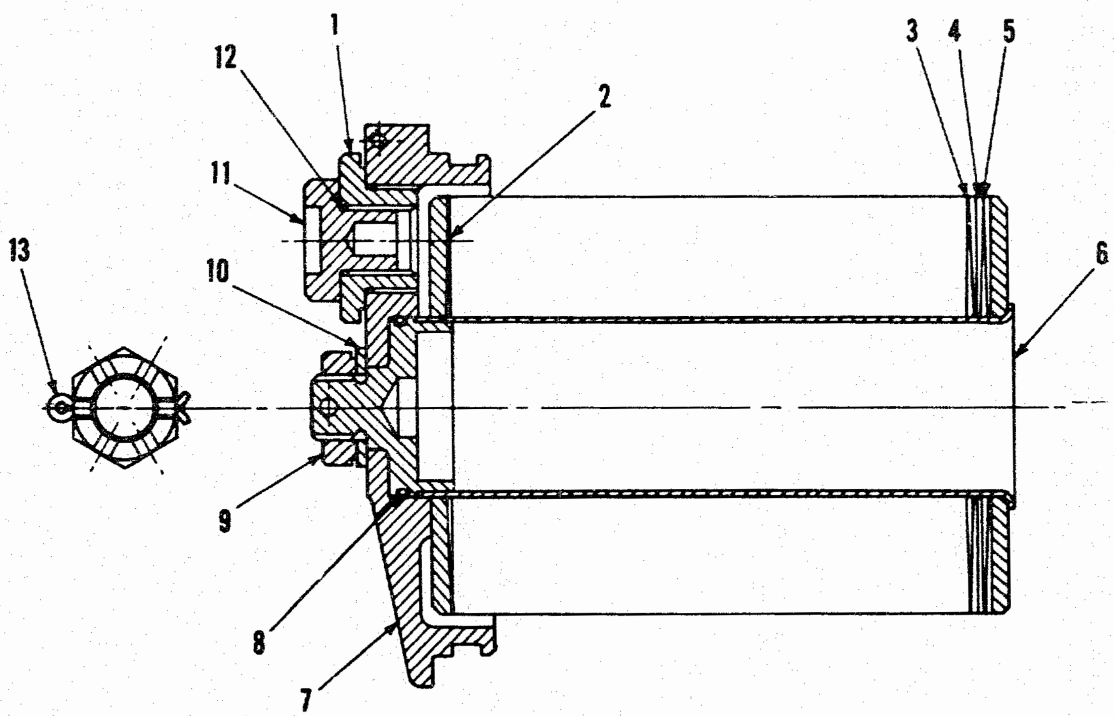
Oil Pump

Oil from the tank enters at the bottom part of three ports on the right side of the accessory component gearbox assembly. It travels through internal passages in the casting to the rear section of the duplex pump. The pump is duplex in construction since it has individual separated sections. The rear half is the pressure section while the front half is the scavenge section. The pump is the gear-type and is splined into the hydraulic pump gearshaft. The pump is located at the right front of the gearbox assembly.

Main Oil Filter

See Figure 49.

Oil from the pump travels through passages in the gearbox assembly casting to a filter housing assembly. See Figure 50. This filter housing assembly is located forward on the intermediate case flange. It consists of a housing, valves, and a main oil filter element. The main oil filter element is made up of alternate screens and spacers around an inner filter element assembly. Oil



1. BUSHING
2. SPACER END PLATE
3. INLET SPACER
4. SCREEN
5. OUTLET SPACER
6. INNER FILTER ELEMENT
7. COVER
8. PREFORMED PACKING
9. SLOTTED SHEAR NUT
10. SHANK WASHER
11. PLUG
12. PREFORMED PACKING
13. COTTER PIN

L-7450

Main Oil Filter Element

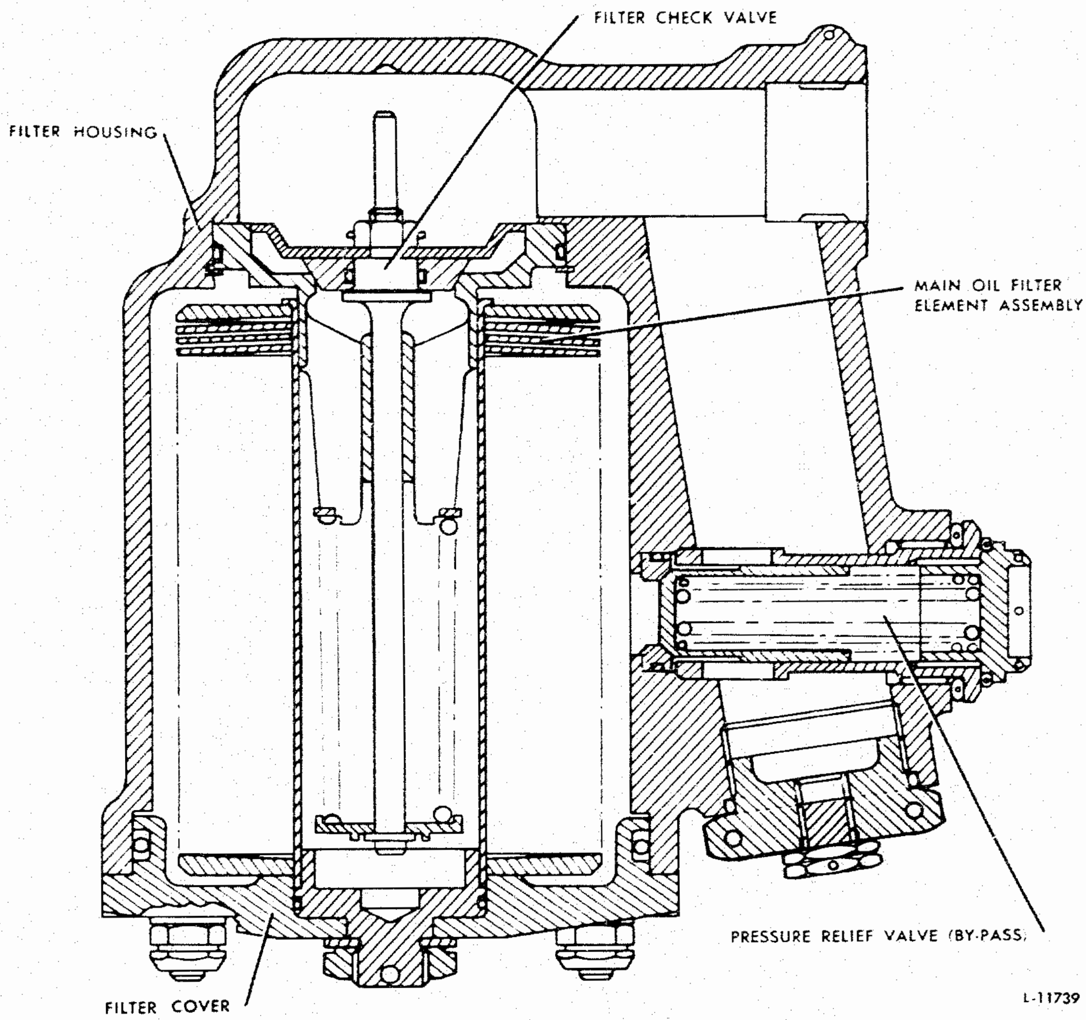
Figure 49

flow is from outside the disks toward the center of the perforated baffle.

A spring-loaded return filter valve is mounted in the filter housing at the baffle outlet to prevent any leakage of oil into the engine during periods of inactivity. Also included in the filter housing is an oil pressure relief valve assembly (by-pass) which we will discuss below.

Oil Pressure Relief Valve Assembly (By-Pass)

A spring-loaded by-pass valve is mounted in the filter housing casting. Its inlet is from the chamber surrounding the main oil strainer. Its outlet is to a chamber downstream of the screen assembly and filter valve. The purpose of the by-pass valve is to allow oil to go around the screen assembly if the screens become clogged.



Filter Housing Assembly

Figure 50

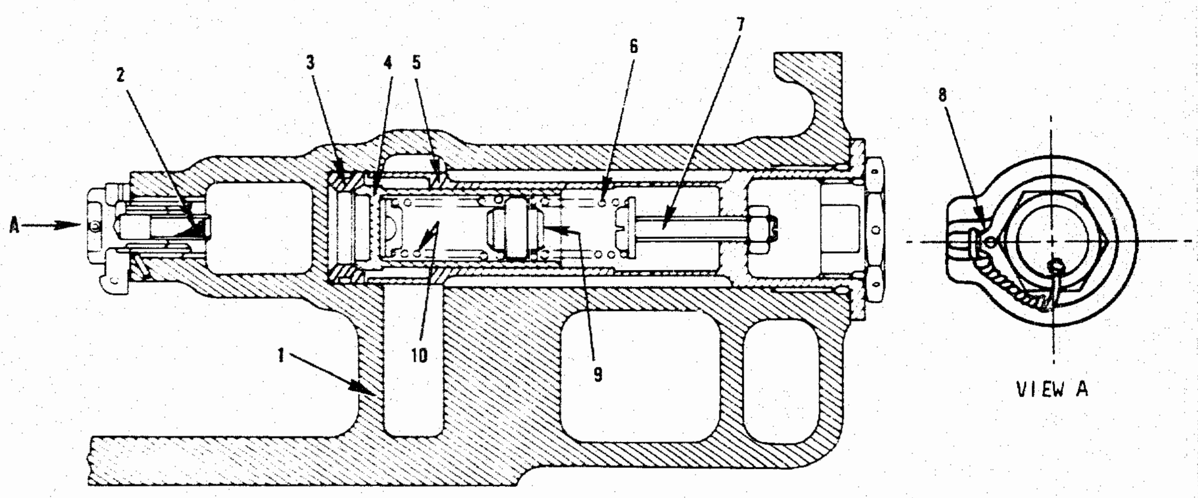
Main Oil Filter and By-Pass Warning System

To prevent the engine from operating with a contaminated oil system and as a maintenance aid, an airframe supplied differential pressure switch (Delta P) connects with two ports on the bottom of the filter housing assembly. This differential pressure switch is actuated when the pressure differential of the oil entering the filter housing and the oil leaving the filter housing reaches 50 ± 1.5 psi as indicated by a warning light. When the pressure differential reaches this point, it is highly probable that the filter is becoming clogged but is still providing filtered oil since the oil does not by-pass the filter until the differential pressure reaches 67 ± 2.5 psi. Therefore this system warns the maintenance personnel and/or pilot that the oil filter is becoming clogged.

Pressure Relief Valve Assembly

See Figure 51.

Mounted in the accessory component gearbox assembly is the pressure relief valve assembly. This is a conventional relief valve which when open, permits oil to flow from the chamber downstream of the strainer valve to the pump inlet passage.



1.	Gearbox	6.	Outer Spring
2.	Strainer	7.	Adjusting Screw
3.	Valve Seat	8.	Do Not Lockwire Over Jet Port
4.	Valve	9.	Intermediate Spring Seat
5.	Valve Body	10.	Inner Spring

Pressure Relief Valve
Figure 51

External Tubes

A tube attached to the middle of three outlets on the lower right front of the gearbox assembly carries the oil forward to the lower connection on the oil strainer housing. From the topmost filter housing connection on the oil strainer housing, a large tube carries the oil rearward to the adapter on the gearbox. At this point, the oil is influenced by the pressure relief valve as outlined in the above paragraph. From the adapter on the gearbox, a tube carries oil to an adapter on the diffuser case. This adapter permits oil to flow internally to the No. 4 and No. 5 bearings through internal tubing, and also permits oil

to flow rearward through a tube to an elbow on the 3 o'clock position of the exhaust case. Internal tubing carries the oil internally to the No. 6 Bearing. A small tube connected to the strainer assembly carries oil to the center of the oil adapter located at the 6 o'clock position at the intermediate case front flange location. From here, it flows internally to the No. 2, No. 2 1/2 and No. 3 Bearings. Another tube from the strainer housing runs underneath the engine forward to an elbow at the 4 o'clock position in the inlet case and from there, internal tubing carries the oil to the No. 1 Bearing.

Internal Tubes and Passages

No. 1 Bearing

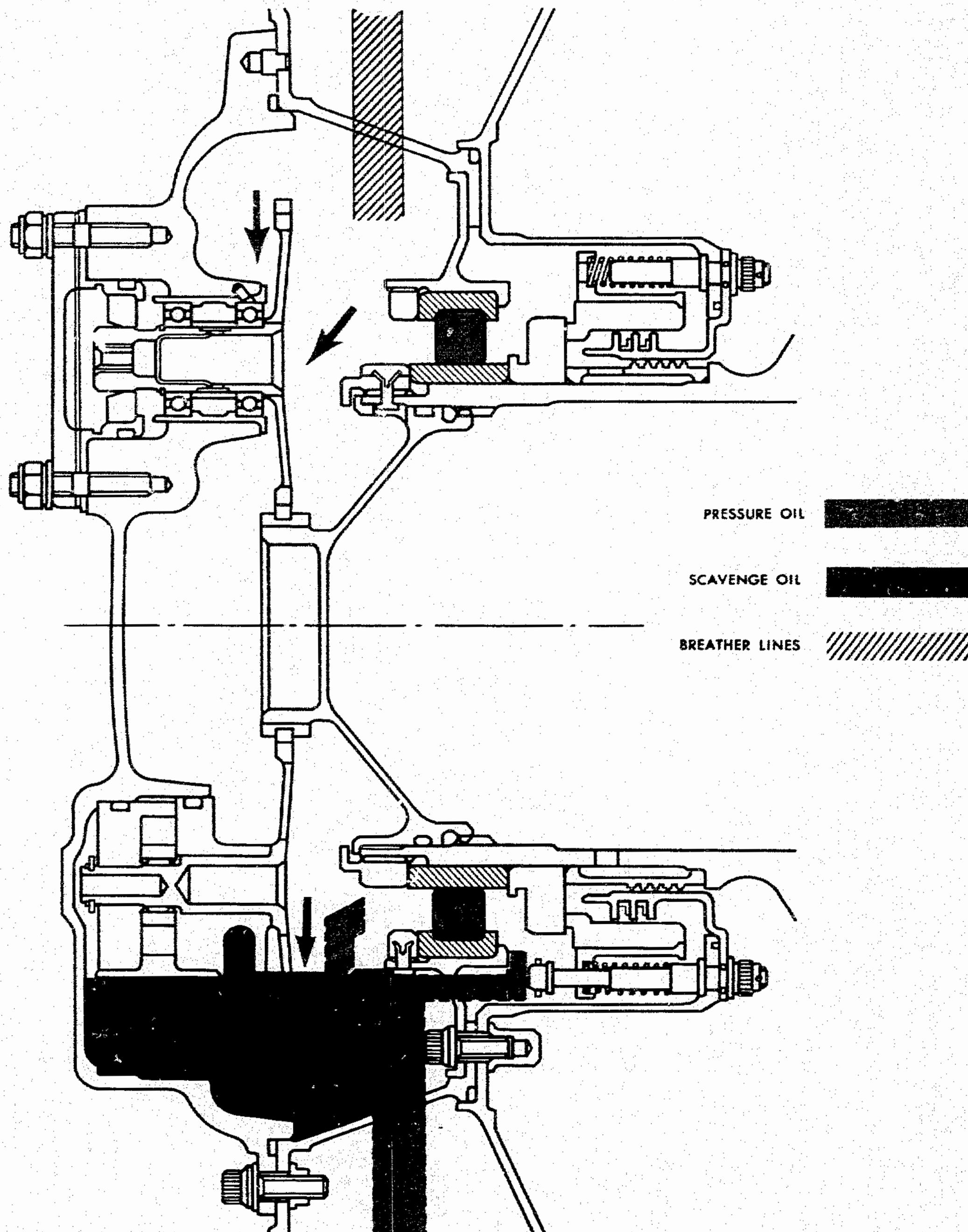
See Figure 52.

Oil from the front pressure tube enters the inlet case assembly through a fitting at the outer end of the 4 o'clock strut. A tube inside the strut carries the oil to a fitting on the inside diameter of the inner shroud. An oil transfer tube with "O" ring seals on the ends, carries the oil to the No. 1 Bearing oil nozzle assembly. Oil that flows to the nozzle assembly passes through a screen inside the assembly and then to two metering plugs. These plugs jet oil into the No. 1 Bearing rollers and the No. 1 Bearing seal assembly.

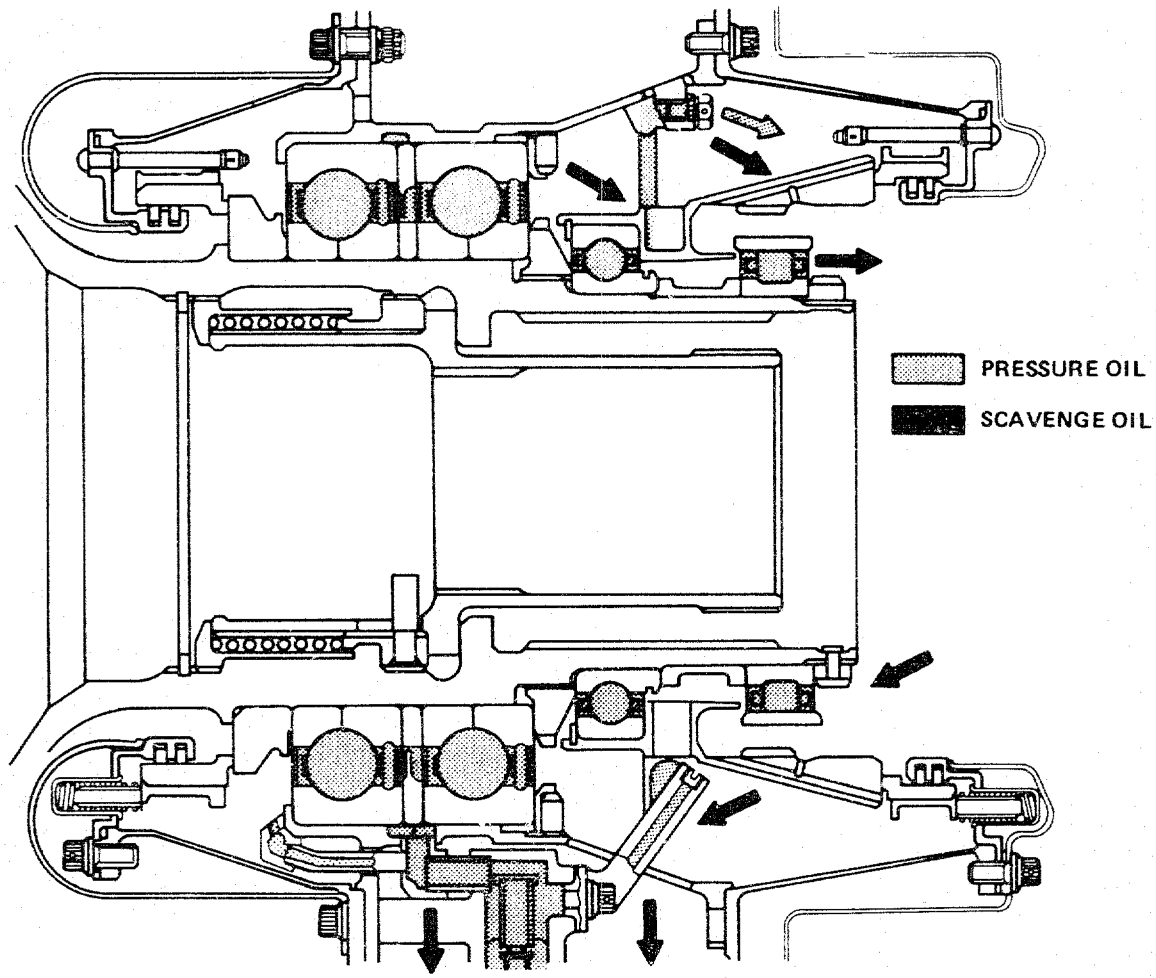
No. 2, No. 2 1/2, No. 3 Bearings

See Figure 53.

Oil from the pressure and scavenge oil adapter at the 6 o'clock front flange location of the intermediate case is passed inward via a transfer tube. The upper end of the transfer tube fits into the lower end of the compressor intermediate bearing oil pressure tube. This latter tube has a perforated flange welded to its lower end. The rim of this flange fits into the adapter liner, with an "O" ring for sealing. The top of the oil pressure tube fits into the compressor intermediate bearing oil pressure adapter. This adapter is to change the contour of the flat tube to a round tube. The oil pressure tube is flat because it travels through the six o'clock intermediate compressor vane. From the top of the adapter, a round tube carries the oil to a strainer assembly. This strainer is threaded into an adapter, with an "O" ring for sealing. The adapter is held fast to the bottom center outside of the No. 2 Bearing housing with studs and nuts. From the oil adapter, a forward-facing passage joins a tube. The front end of the passage is plugged, and oil is delivered through an opening to the baffles of the No. 2 Bearing. An oil manifold is attached to the rear of the adapter and bolted to the bearing housing. This manifold is semi-circular and mounted on the right side of the bearing housing. From the bottom of the manifold, a jet plug delivers oil to both the No. 2 1/2 and No. 3 Bearings. Oil reaches these bearings through openings in the No. 2 1/2 Bearing housing. At the 12 o'clock position of the manifold, a jet delivers oil to the forward section of the No. 3 Bearing seal.



No. 1 Bearing Oil Schematic
Figure 52



Typical No. 2, No. 2 1/2, and No. 3
Bearing Oil Schematic

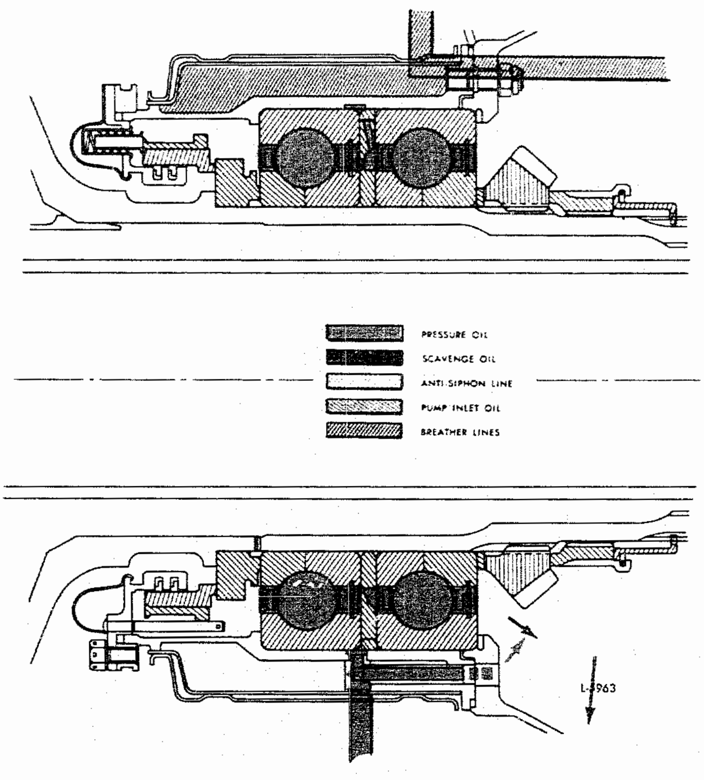
Figure 53

ENGINE - DESCRIPTION AND OPERATION

No. 4 and No. 5 Bearings

See Figures 54, 55, and 56.

Oil from the external tube is brought through the tube in the four o'clock strut of the diffuser assembly to the rear area inside of the inner bolt circle. A ferrule joins the strut tube and oil pressure tube adapters. A strainer is located inside of the adapter. The adapter and a No. 4 Bearing oil transfer tube assembly are bolted together to a pad inside the diffuser case. The transfer tube rear bolt flange fits between the adapter bolt flange and the case pad.

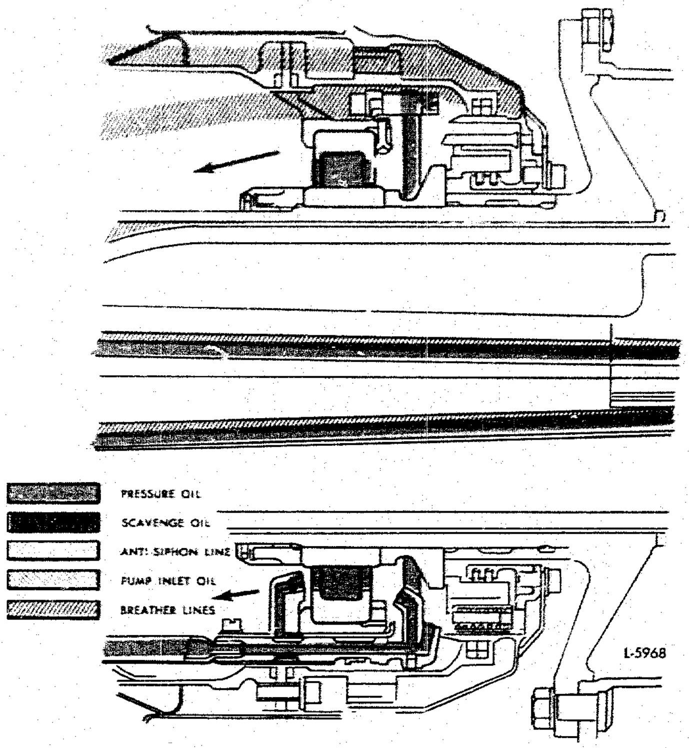


Typical No. 4 Bearing Oil Schematic (JT3D-1-MC6 Shown)

ENGINE - DESCRIPTION AND OPERATION

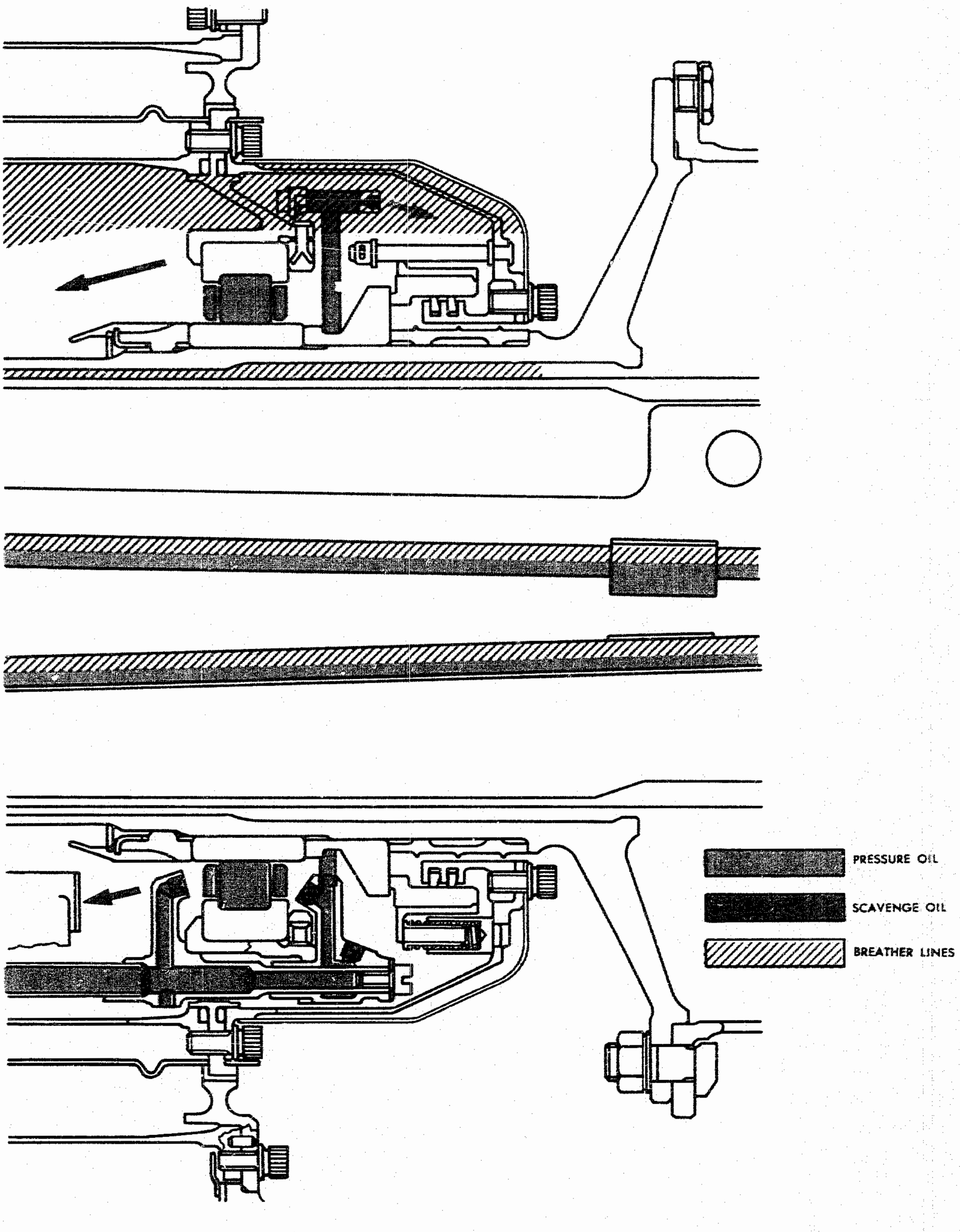
The transfer tube leads oil from the adapter forward to the oil baffle between the two ball bearings that together made up the No. 4 Bearing. A small oil tube leads oil from the left side of the adapter to the angled accessory drive shaftgear bearing. The housing for this bearing carries this tube by a bolt flange. The tube is a slip fit into the oil pressure tubes adapter. From an opening in the rear of the adapter, the No. 5 Bearing oil pressure tube carries oil rearward through the No. 5 Bearing support weldment. A nozzle assembly, containing a jet, is clamped over the holes in the tube in front of the No. 5 Bearing. The tube passes through the No. 5 Bearing housing and ends in a manifold that carries two jets, and delivers the oil to the top and bottom of the rear side of the bearing. This manifold is bolted to the No. 5 Bearing housing.

These two jets feed oil to the rear of the No. 5 Bearing and to the carbon seal and seal plate. The jet from the nozzle assembly just ahead of the bearing feeds oil to the front of the rollers.



No. 5 Bearing Oil Schematic (JT3D-1-MC6)

Figure 55



No. 5 Bearing Oil Schematic
(JT3D-1 and JT3D-1-MC7)
Figure 56

No. 4 1/2 and No. 6 Bearings

See Figures 57, 58, and 59.

Oil from the rearmost external tube is brought through a strainer into the engine. The oil passes through the center of a rod in the three o'clock strut of the turbine exhaust case. The tube that carries the oil is the inside of the No. 6 Bearing support rod. The inner end of the support rod is fastened to the No. 6 Bearing internal oil pressure tube by a through bolt fitting. The other end of the tube connects to the No. 6 Bearing oil sump assembly. A strainer is located at this point. Inside of the sump assembly, the oil flow is divided, part flowing to the No. 6 Bearing nozzle assembly, which is bolted to a flange near the inside upper rim of the sump. The No. 6 Bearing gets its oil from this nozzle. The other flow inside of the sump tubes is to an outlet at the sump center. From this point, the oil is led forward into a nozzle assembly. This nozzle assembly is threaded into the center outlet of the sump assembly, and carries a metering jet inside the nozzle tube. The nozzle assembly passes through the center of the No. 6 Bearing oil suction pump pinion, and discharges the oil into the center of the No. 6 Bearing oil seal sleeve. The No. 4 1/2 Bearing shield assembly fits into the forward end of the sleeve using two bronze rings for seals. Four oil tubes in this assembly carry the pressure oil forward from the sleeve and discharge it to a tapered space between the front two of three seals. These seals fit tightly to the internal taper of the inside of the front compressor turbine shaft. Drilled holes through the shaft allow oil to run out into a space just ahead of the No. 4 1/2 Bearing. This bearing forms the rear wall of this space and in this way receives its lubrication.

Front Accessory Section

See Figure 52.

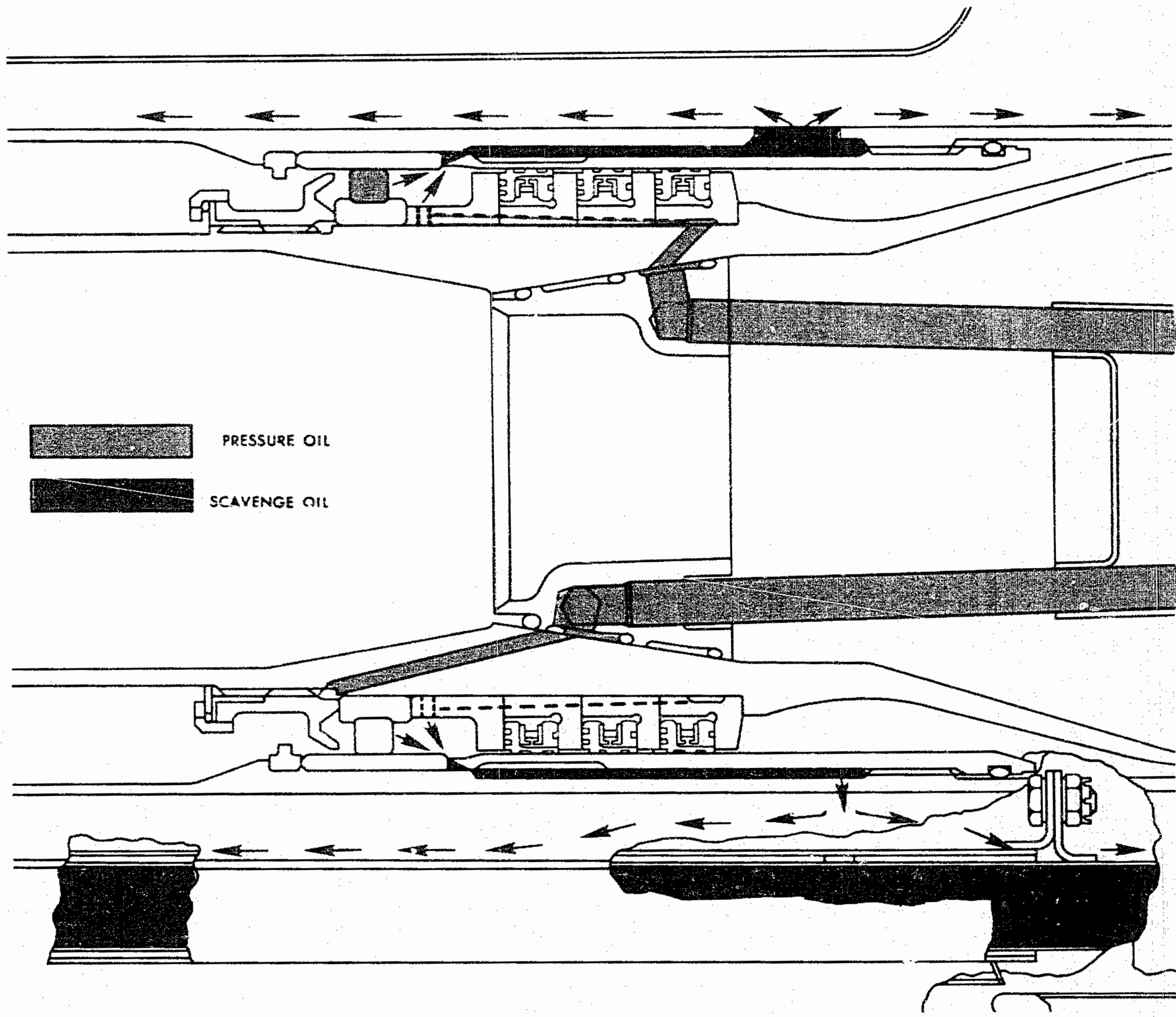
No. 1 Bearing oil, previously discussed, provides the lubrication for the front accessory section gears and bearings. This is accomplished by splash and gravitation in the annulus formed by the front accessory support and the No. 1 Bearing support.

Accessory Component Drive Gearbox Assembly

See Figure 48.

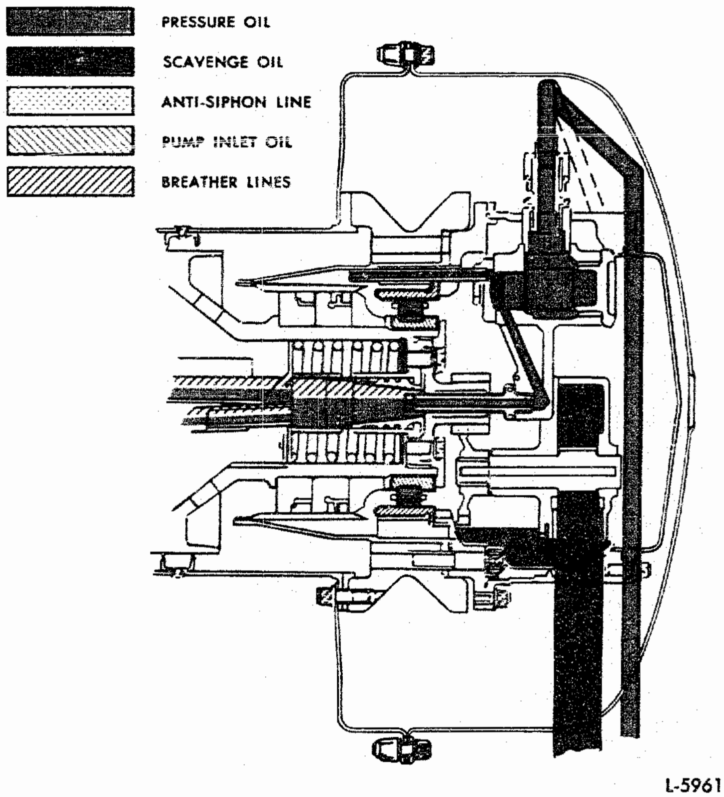
Lubrication for the front bearings of the fuel pump and the fuel control shaft bearings in the gearbox assembly is delivered by passages in the casting and jets. Splash and spray from the above and from return oil of the No. 4 and No. 5 Bearing area provide the remainder of the lubrication in this section.

ENGINE - DESCRIPTION AND OPERATION



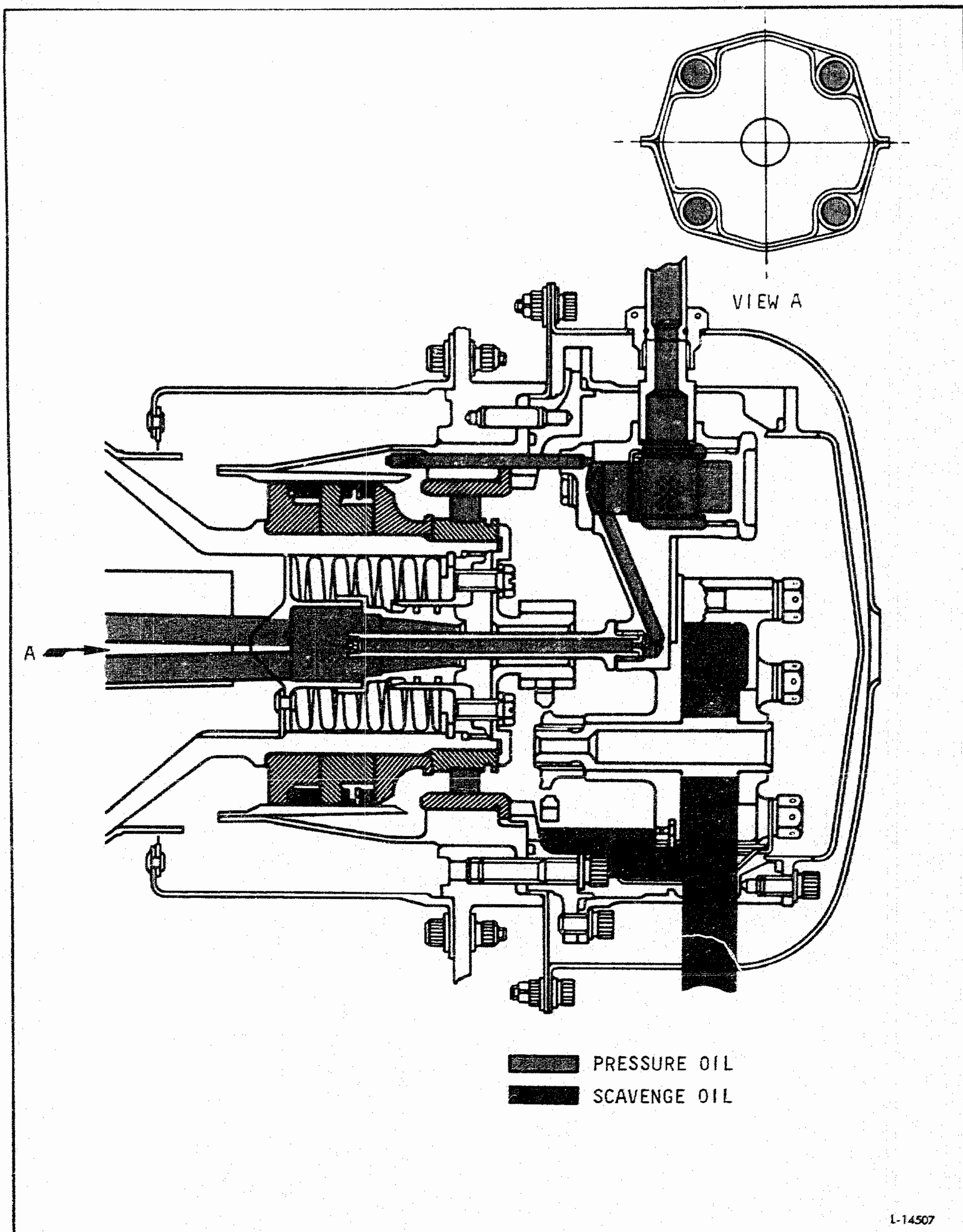
No. 4 1/2 Bearing Oil Schematic

Figure 57



No. 6 Bearing Oil Schematic (JT3D-1-MC6)

Figure 58



No. 6 Bearing Oil Schematic

Figure 59

ENGINE - DESCRIPTION AND OPERATION

Angled Accessory Drive Shaftgear Bearings

See Figure 48.

The angled accessory drive shaftgear bearing oil tube carries oil to the upper bearing, roller type, of the accessory drive shaftgear. The discharged oil from this roller bearing that falls downward in the bearing housing is used to lubricate the lower shaftgear ball bearing.

Scavenge System

See Figure 48.

General

The engine uses the dry sump system. The four scavenge pumps with five scavenge sections (one is dual sectioned) are capable of pumping about three times the quantity of oil that the pressure pump can handle. Each scavenge pump draws oil from a sump. The oil is routed to the cooler and tank through internal passages and external tubing.

No. 1 Bearing and Front Accessory Section

See Figure 52.

Oil from the No. 1 Bearing drains to the low point between the No. 1 Bearing front support and the front accessory drives support which forms a sump for this oil. Oil from all of the front accessory gears and bearings drains down between these supports to the same sump.

A conventional gear type pump is supported on a boss on the rear face of the front accessory drive support. The pump is driven by the front accessory drive gear. This pump is located in the sump with a strainer inlet in the bottom of the pump. Scavenge oil from the pump travels through a drilled passage in the front accessory drive support to an "O" ring sealed transfer tube; then to a tube inside the eight o'clock inlet vane. An external tube connected to a fitting on the outside of the outer shroud at the eight o'clock position, carries the oil to the rear underneath the engine to the approximate front flange location of the intermediate case where it connects to an elbow on a tube from the No. 2, No. 2 1/2 and No. 3 Bearing oil manifold.

No. 2, No. 2 1/2, No. 3 Bearings and Main Accessory System

See Figure 53.

Scavenge oil from the No. 2, No. 2 1/2 and No. 3 Bearings drains into the No. 2 Bearing support assembly. Oil first drains to the rear of the center support of this assembly. This oil passes through holes in the bottom of the center support to the space formed by the bearing assembly's front support, the rear support, and the inner shroud of the compressor intermediate case assembly. Oil

then runs down through the lower vanes of the intermediate case assembly to the 6 o'clock vane. The No. 2 Bearing oil pressure tube does not fully fill this vane. There is room around it to allow drainage of scavenge oil. There are holes through the support ring at the lower end of the tube. Scavenge oil drops through these holes and through the No. 2 Bearing oil drain adapter into the pressure and scavenge oil adapter assembly. This adapter assembly is mounted under the compressor intermediate case assembly. A sump at the bottom center of the gearbox assembly case collects the oil. All scavenge oil from the gearbox accessory gears and bearings also drains to this same sump. The scavenge section of the duplex pump scavenges the sump of oil.

No. 4 Bearing

See Figure 54.

Scavenge oil is discharged from the front of the forward bearing and the rear of the rear bearing. Space in the seal housing allows oil from the front to drain back to the rear of the No. 4 Bearing support structure in the diffuser case. Oil from the rear bearing drains directly to the same place. The splash from this rear bearing scavenge oil forms the lubrication for the gears and scavenge pump idler bearings in this area. All scavenge oil then drains to a sump formed where the No. 5 Bearing support weldment joins the No. 4 Bearing support structure.

The lower section of the dual scavenge pump, draws oil from the sump. The oil scavenge tube for this pump is a passage in the pump housing casting. There is an inlet strainer located in the pump housing. The pump shafts are vertically mounted and driven by a gear train from the accessory drive gear ("bull gear"). The pump housing is bolted to the bearing support structure in the diffuser case. The pump outlet tube assembly is flange bolted to the left side of the strut. A tube through this strut carries the oil to a pad outside of the diffuser case. An elbow, a tube, and a connector carry the oil forward into the right front face of the gearbox assembly. Internal passages in the gearbox assembly casting carry the oil to the outlet pad.

No. 4 1/2 and No. 5 Bearings

See Figures 57, 55, and 56.

Scavenge oil from the No. 4 1/2 Bearing is discharged from the rear side of the rollers into a space formed by the No. 4 1/2 Bearing spacer and the No. 4 1/2 Bearing seal liner.

Through slots in front of this liner and in the rear compressor drive turbine shaft, the oil drains into the No. 5 Bearing support weldment. Some of this oil may run forward to the sump at the No. 4 Bearing. The remainder runs aft to a sump formed by the junction of the No. 5 Bearing support weldment and the No. 5 Bearing housing. Scavenge oil from the No. 5 Bearing drains into this same sump.

ENGINE - DESCRIPTION AND OPERATION

The No. 5 Bearing oil scavenge tube dips its rear end into this sump. The tube is bolted into place in the lower part of the No. 5 Bearing support weldment. The forward end of this tube fits into the inlet of the upper scavenge pump. The tube is sealed with "O" rings and a strainer is held inside the pump inlet with a snapring. The scavenge pump is the second section of the dual unit discussed under the No. 4 Bearing scavenge system. The outlet of both sections is common and the oil travel from this outlet was discussed under the No. 4 Bearing scavenge system.

No. 6 Bearing

See Figures 58 and 59.

Scavenge oil is discharged from both sides of the No. 6 Bearing. Oil that is discharged forward can run back through holes in the rear of the seal housing. Oil that is discharged rearward falls into the sump, lubricating the scavenge pump gears as it goes. The sump is a horizontally mounted, cylindrical unit, with a scavenge pump at its bottom. The gear-type pump is driven by a gear which meshes with a pinion. This pinion is at the rear end of the front compressor drive turbine. The pump inlet is at the bottom of the sump, and is covered by a strainer. The pump outlet is at the six o'clock position of the sump assembly. A tube connects this point to a tube assembly passing through the six o'clock exit strut to the rear of the No. 6 Bearing support rod. Tubes carry the oil forward along the left side of the engine and discharge it into a fitting at the left rear of the rear gearbox housing.

Angled Accessory Drive Shaftgear Bearings

Scavenge oil from the accessory drive shaftgear bearings, inside of the diffuser case, falls through a tube to the rear gearbox housing. This tube is located just forward of the accessory drive shaft. Through internal passages in the rear gearbox housing the oil reaches the sump. Oil from the accessory drive gears and bearings also falls into this same sump.

Oil Cooling System

From the oil outlet pad on the gearbox housing assembly, the oil is piped to the fuel-oil cooler, then to the air-oil cooler and from the air-oil cooler to the oil tank. These units are airframe supplied parts.

Fuel-Oil Cooler

This is a cylindrical unit mounted in the front lower right quadrant of the diffuser case. Fuel flows through tubes in the core of the cooler, and oil circulates within the housing and around the outside of the core tubes. Engine oil which has not been heated sufficiently by engine operation to require cooling is prevented from entering the cooler by a thermostatic valve located in the inlet connection of the cooler. This unit will be discussed further in the oil chapter. See Chapter 79.

NOTE: On Douglas engines the fuel-oil cooler and the oil tank are airframe supplied.

Breather System

General

All breathing is done through the gearbox assembly. Inside this assembly and attached to the fuel pump drive shaft is an impeller which serves as a centrifugal device to remove oil from the air. Internal passages and external tubing are used to connect all breathing points to the gearbox assembly. An overboard breather tube furnished by the airframe manufacturer is attached to an adapter on the upper left side of the gearbox assembly.

No. 1 Bearing and Front Accessory Breathing

See Figure 52.

The space behind the front accessory drive support and the No. 1 Bearing is vented by means of an "O" ring sealed transfer tube, to a tube through the 12:30 o'clock vane than to a fitting on the outside of the outer shroud of the compressor inlet guide vane and shroud assembly. A connector and a flexible tube carry breathing air from the outer shroud fitting to the external breather tee. On outboard engines, this flexible tube is connected to the oil tank. This tee is bolted to the compressor intermediate case at the two o'clock position between the mounting rings. A tube from the tee leads inward through a vane to the No. 2 Bearing area.

No. 2, No. 2 1/2, and No. 3 Bearings Breathing

See Figure 53.

This space is formed by the No. 2 Bearing front support and the No. 2 Bearing seal on the forward side. The No. 2 Bearing rear support and the No. 3 Bearing seal form the rear wall. The inner shroud of the compressor intermediate case forms the outside wall of the space. This space breathes through the six o'clock vane and the No. 2 Bearing oil drain adapter. The No. 2 1/2 and No. 3 Bearings use this same breathing space and passages.

No. 4, No. 4 1/2 and No. 5 Bearings Breathing

See Figures 54, through 57.

The forward wall of the compressor-to-turbine space is formed by the No. 5 Bearing support structure in the diffuser case and the seal just ahead of the No. 4 Bearing. The rear wall is the No. 5 Bearing seal system. The inner wall is the structure of the No. 5 Bearing support system. The No. 4, No. 4 1/2 and No. 5 Bearings, the accessory drive gearing, the accessory drive adapter (elbow) assembly and the No. 4 and No. 5 Bearings oil scavenge pump are all vented to this space. The accessory drive adapter vents through the strut that carries the accessory drive shaft. The twelve o'clock diffuser case strut is open from this

space to a pad on the top of the diffuser case. An elbow bolted to this pad connects to a tube. The forward end of this tube is connected to the tee that was mentioned in connection with the No. 1 Bearing and front accessory case breather.

No. 6 Bearing Sump

See Figures 58 and 59.

This area has two possible breathing passages. One is through its scavenge system. The other is through the No. 4 1/2 Bearing lubrication system. The tubes in the No. 4 1/2 Bearing oil tube shield assembly do not run full of oil. The jet tube that feeds oil into the sleeve that is their common rear termination is not tight on this sleeve. Air from the No. 6 Bearing area can enter these tubes along with the No. 4 1/2 Bearing oil. Because the tubes taper outward as they go forward, centrifugal force is used to make the oil move forward to the No. 4 1/2 Bearing. These tubes, therefore, do not have to run full of oil under pressure. The No. 6 Bearing area breathing air follows the same path as the No. 4 1/2 Bearing oil supply and eventually breathes through the same passages used by the No. 4 1/2 Bearing oil supply. Air flow will always be in the same direction as oil flow in these tubes. This is because of the slight pressure that is created in the No. 6 Bearing area by leakage of 9th stage air through the No. 6 Bearing carbon seals.

Accessory Component Drive Gearbox Assembly

In the foregoing it was shown how all breathing is to the gearbox assembly. Also as has been mentioned, inside of this case and mounted on the fuel pump drive shaft is a centrifugal device to remove oil from the air. It resembles a pump impeller with its vanes enclosed on both sides. The inside diameter of the breather assembly is vented to inside the front end of the fuel pump drive shaft. The forward end of this shaft is open to a passage in the cover of the gearbox assembly. An internal passage in the cover casting leads to an outlet at the top right hand corner of the casting. The breather adapter is mounted on the gearbox rear housing in this area.

Cooling Air System

Cooling air for the third and fourth stage disk and seals is furnished by the front compressor. Leakage at the rear of the ninth stage blade platform enters the front compressor rotor assembly through holes in the front compressor rear hub. The air then enters the front end of the front compressor drive turbine shaft and passes rearward through the hollow shaft. The cooling air leaves the shaft through holes in the turbine disk spacer between the third and fourth disk and in the turbine rotor hub. It flows outward through a hole in the air seal and past a knife-edge seal in the hub to cool the rear face of the third stage turbine and the rear face of the fourth stage turbine. Leakage past a triple seal between the third and fourth stage turbine cools the front face of the fourth stage turbine. A hole in the extruded flange of the second stage turbine permits this cooling air to be static in the area above the seal between the second and third stage turbine.

ENGINE - DESCRIPTION AND OPERATION

Rear compressor air from the sixteenth stage leaks by the air seal of the rotor and enters the diffuser case inner cavity forward of the No. 4 Bearing heatshield. It then passes through holesin the inner periphery of the case to a chamber formed by the diffuser case inner and outer walls. From here it passes through holes in the diffuser case rear flange to the air space between the No. 5 Bearing support to enter the area between the turbine nozzle inner case and the first stage turbine seal support. The air then leaks past the air seals at the front of the first stage turbine disk to mix with the exhaust gases cooling the front of the turbine as it goes or enters larger holes in the extended inner flange of the disk and then past knife-edge seals to cool the rear face of the first stage turbine and the front face of the second stage turbine.

ENGINE - TROUBLESHOOTING

1. General

A. Troubleshooting is a process of identifying engine problems through observation and evaluation of engine behavior. When an engine develops a problem, maintenance personnel must evaluate the symptoms and identify the cause of the problem, using evidence which supports a certain cause or disqualifies other causes. In order to save time, the most probable cause, as determined by maintenance experience and by the recommendations of this section, should be examined first.

B. Before attempting to work on an engine which has been reported as malfunctioning, it is important to know as much as possible about the engine. Not only is the engine's behavior at the time of its malfunctioning important, but also the recent history of the engine should be considered: time since overhaul or major component replacement, time since the last trim or ground check, or the relationship in service time between the engine and other engines in the aircraft should be taken into account. Consult the pilot's flight report, engine log books, and any other available sources.

C. These troubleshooting procedures are prepared with the assumption that maintenance personnel are familiar with the design and structure of the JT3D Turbofan engine. See the Description sections in the engine and accessory component chapters for details on the various areas of the engine.

D. Approved removal and installation procedures for various engine parts and components are described in their respective sections in this manual. Special assembly procedures, special torques, etc. are listed in "Fits and Clearances" portions of applicable Removal/Installation or Inspection/Check sections: all maintenance procedures not covered by special limits shall conform to the techniques and limits in the "Standard Maintenance Procedures" portion of Chapter/Section 72-0, Dismantling/Assembly.

2. Troubleshooting Section Structure

A. The troubleshooting section is divided into general engine and power response problems and individual system problems and troubleshooting procedures. The "Power and Engine Response Problems" section provides a list of common engine problems and either indicates the most likely cause and appropriate troubleshooting procedures or makes reference to one or more system troubleshooting sections. When troubleshooting an engine malfunction, the "Power and Engine Response Problems" section should first be consulted to determine what systems may be responsible. Reference is then made to the most likely component in that system responsible for the problem.

ENGINE - TROUBLESHOOTING

B. Table of Contents

C. The scope of this section is to locate the cause of engine malfunction and to prescribe corrective action. Detailed inspection and check procedures on engine subassemblies and accessory components are found in the applicable engine or accessory component subsection of this manual; where detailed inspection of a subassembly or component would be helpful and practical in troubleshooting the engine, specific reference will be made to the section in which that procedure is found.

D. For detailed treatment of engine-related systems not part of the basic JT3D engine, consult the applicable airframe maintenance manual.

3. Subsystem Troubleshooting Procedures

A. Specific subsystem problems are listed in the following paragraphs, together with test procedures to help isolate the problem, and corrective action required. Possible causes are listed in order of probability, from highest to lowest.

ENGINE - TROUBLESHOOTING

4. Power And Engine Response

Possible Cause	Test Procedure	Corrective Action
A. No (Or Limited) N1 Or N2 During Starting		
See Engine Indicating System.		
B. No Light-Off During Starting		
(1) Defective Ignition System	See Ignition System.	
(2) No Fuel To Combustion Section	(a) Check fuel shutoff lever rigging (see applicable airframe maintenance manual).	
	(b) Check fuel pump discharge pressure (see Fuel System).	Replace fuel pump. If fuel pump output normal replace P&D valve. If problem is not corrected replace Fuel Control.
(3) Defective Airframe/QEC Fuel System	See applicable airframe maintenance manual.	
C. Impending Hot Start		
(1) Gaspath Damage	Check inlet and tail pipe area for damage.	Replace engine if damage is found.

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
C. Impending Hot Start (Continued)		
(2) Defective Fuel System	(a) Check for fuel control schedule shift by comparing fuel flow of suspect engine with fuel flow of other engine in aircraft.	Replace defective fuel control unit. If fuel control replacement does not correct problem, replace P&D valve (Section 73-4-1).
	(b) Check for premature starter cutout (see applicable airframe maintenance manual).	NOTE: Perform "Clear Engine Procedure" in Adjustment/Test section before restarting engine.
D. Hung Start (No Acceleration To Idle; N2 And EGT Stable)		
(1) Defective Fuel System	See fuel system "Hung Start".	
(2) Defective Bleed System	Check bleed valves for proper closing schedule (see Adjustment/Test Section).	See Surge Bleed System. "Surge Bleed Not Operable Or Off-Schedule"
(3) Defective Airframe/QEC Fuel System	See applicable airframe maintenance manual.	
(4) Premature Starter Cutout	See applicable airframe maintenance manual.	
E. No Or Abnormal Power Lever Response		
(1) Defective Fuel System	(a) Check fuel pump discharge pressure (see Fuel System).	
	(b) Check fuel control rigging (Section 73-2-2).	Re-rig as necessary.

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
E. No Or Abnormal Power Lever Response (Continued)		
	(c) Check for leaks in fuel control Ps4 sense line.	Retorque or replace line as necessary. If no leaks found, replace fuel control.
(2) Restricted Airframe/QEC Fuel System	See applicable airframe maintenance manual.	
F. Power Lever Misalignment		
(1) Surge Bleed System Defective or Off-Schedule	Check bleed valve operation (see Adjustment/Test).	See Surge Bleed System.
(2) Gaspath Deterioration	Conduct ground performance or data plate speed check.	Wash engine gaspath and/or check turbine nozzle condition.
(3) Defective Fuel System	(a) Check for proper fuel control rigging.	Re-rig as necessary.
	(b) Check fuel control Ps4 sense line for leaks.	Retorque or replace line as necessary.
	(c) Check that the fuel pressurizing and dump valve is not in dump mode.	Replace defective P&D valve (Section 73-4-1).
	(d) Check fuel control for proper trim.	Retrim as necessary.
(4) Airframe/QEC Fuel or Bleed Air Malfunction	See applicable airframe maintenance manual	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
G. Unable To Attain Take-Off EPR		
(1) Surge Bleed Valve Off-Schedule	Check bleed valve operation (see Adjustment/Test).	See "Surge Bleed System".
(2) Gaspath Damage or Deterioration	(a) Check inlet and tailpipe area for FOD.	Blend or replace fan blades as necessary. If FOD beyond repair, replace engine or module.
	(b) Conduct ground performance or data plate speed check.	If gaspath deterioration suspected, wash engine (Section 72-0, Engine - Cleaning).
(3) Leak or obstruction in Pt7 Line	See Indicating System under "Low EPR".	
(4) Defective Fuel System	See Fuel System. "Unable To Attain Take-Off EPR".	
(5) Airframe/QEC Fuel or Bleed Air Malfunction	See applicable airframe maintenance manual.	
H. EGT Limited		
(1) Surge Bleed Valve Off-Schedule	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System.
(2) Gaspath Damage or Deterioration	(a) Check inlet and tailpipe area for FOD.	Blend or replace fan blades as necessary. If FOD beyond limits, replace engine.
	(b) Conduct ground performance monitoring or data plate speed check.	If gaspath contamination is suspected, wash engine. (Section 72-0, Engine-Cleaning).

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
H. EGT Limited (Continued)		
(3) Defective Indication System	See Indicating System, under "EGT Indication High".	
(4) Airframe/QEC Bleed Air Malfunction	See applicable airframe maintenance manual.	
I. N_1 Limited		
(1) Defective N_1 or EPR Indicating System	See Indicating System "Leaking Pt7 System".	Disconnect Pt7 line and free if obstructed. Torque loose fittings. If no discrepancies found, replace N_1 tach generator or gage.
(2) Leaking Thrust Reverser Seal	See applicable airframe maintenance manual.	Repair or replace thrust reverser.
(3) Large Exhaust Nozzle Area	Measure exhaust nozzle area. See applicable airframe maintenance manual.	Resize nozzle.
(4) Gaspath Damage or Deterioration	Check fan blades for excessive blending or FOD.	Blend or replace fan blades as necessary.
(5) Gaspath Contamination	Conduct ground performance monitoring check.	Wash engine (Section 72-0, Engine-Cleaning).

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
J. N2 Limited		
(1) Surge Bleed Valve Off-Schedule	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System.
(2) Gaspath Damage or Deterioration	(a) Check inlet and tailpipe area for FOD.	Replace engine if damage is found.
	(b) Conduct ground performance monitoring or data plate speed check.	If gaspath contamination is suspected, wash engine. (Section 72-0, Engine-Cleaning).
(3) Defective N2 or EPR Indicating Systems	(a) See Indicating System Leaking Pt7 System	Disconnect Pt7 line and free if obstructed. Torque loose fittings.
		If no discrepancies found, replace N_2 tach generator or gage.
K. Slow Acceleration		
(1) Defective Fuel Control Schedule	Check Ps4 sense line for leaks.	Retorque or replace line as necessary; if no leaks, replace fuel control.
(2) Surge Bleed Valve Off-Schedule	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System.
(3) Combustion Chambers Shifted Rearward	Conduct combustion chamber isotope inspection (Section 72-0, Inspection/Check)	Replace chambers as necessary.
L. Auto Acceleration (Power Increase Without Power Lever Movement)		
Loss of N2 Sense at Fuel Control		Replace fuel control.

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
M. Fluctuating Power Level		
(1) Surge Bleed Valve Off-Schedule	Check Bleed valve operation per Adjustment/Test.	See Surge Bleed System.
(2) Defective Fuel System	(a) Check fuel control Ps4 sense line for leaks.	Retorque or replace line as necessary.
	(b) Check fuel pump discharge pressure (see Fuel System).	Replace defective fuel pump; if pump not defective, replace fuel control.
	(c) Check for water in fuel.	
(3) Combustion Chambers Shifted Rearward	Conduct combustion chamber isotope inspection (Section 72-0, Inspection/Check)	Replace chambers as necessary.
N. Flame-Out		
(1) Defective Fuel System	(a) Check fuel control Ps4 sense line for leaks.	Retorque or replace line as necessary.
	(b) Check for failed fuel pump driveshaft by checking fuel discharge pressure (see Fuel System).	Replace defective fuel pump, or if fuel pump not defective, replace fuel control.
	(c) Check airframe fuel system (see applicable airframe maintenance manual).	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
P. Sudden Parameter Shift Or Fluctuation Relative To Other Engines In Aircraft		
(1) Surge Bleed Valve Malfunction	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System.
(2) Indicating System Malfunction	See Indicating System for check of EPR, rpm, and EGT indication systems.	
(3) Gaspath Damage	Check inlet and tail-pipe area for FOD.	Replace engine if damage is found.
Q. Engine Pressure Ratio Varies With Increasing Altitude		
(1) Capped or Obstructed Pt7 Line	Inspect Pt7 line for blockage.	Remove blockage.
(2) Leaking Pt2 Line	Check Pt2 line per Indication System or see applicable airframe maintenance manual.	
R. Fluctuating N1 Or N2 With Other Parameters Normal		
See Indication System, "N1 or N2 Indication Fluctuates".		
S. Off-Idle Surge		
(1) Surge Bleed Valve Defective or Off-Schedule	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System.
(2) Gaspath Damage or Deterioration	Check inlet and tail-pipe area for FOD.	If no damage is found, wash gaspath and check turbine nozzle condition.

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
S. Off-Idle Surge (Continued)		
(3) Rich Fuel Control Acceleration Schedule		Replace fuel control.
(4) Defective Fuel Pressurizing and Dump Valve		Replace fuel P&D valve.
T. High Power Surge		
(1) Gaspath Damage or Deterioration	Check inlet and tailpipe area for FOD.	If no damage is found, wash gaspath and check condition of 1st stage turbine vanes and outer airseal.
(2) Surge Bleed System	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System.
(3) Fuel System		Replace fuel control.

5. Lubrication System

Possible Cause	Test Procedure	Corrective Action
A. No Oil Pressure Indication		
(1) Low Oil Quantity	Check oil level.	Add oil.
(2) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
(3) Defective Main Oil Pump	(a) Open main oil pump discharge port. CAUTION: STAND CLEAR OF PUMP DISCHARGE PORT WHILE MOTORING. (b) Motor engine with starter.	If no oil is discharged, replace main oil pump. (Section 72-0).

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
A. No Oil Pressure Indication (Continued)		
(4) Obstructed Oil Tank-Pump Inlet Passage	(a) Drain oil. (b) Remove main oil pump Section 72-0 and oil tank, (Section 79-3-1). (c) Check oil tank-to-pump passage for obstructions. (d) Reinstall main oil pump (Section 72-0) and oil tank (Section 79-3-1). (e) Refill oil tank.	Clear oil passages.
B. Low Oil Pressure		
(1) Low Oil Quantity	Check oil level.	Add oil.
(2) Defective Air-frame/QEC Indication System	See applicable air-frame maintenance manual.	
(3) Defective Oil Pressure Relief Valve	(a) Drain oil. (b) Remove oil pressure relief valve (Section 72-0). (c) Check preformed packing for damage. NOTE: If packing is undamaged and valve is suspect, inspect old valve for internal binding (Section 72-0). (d) Refil oil tank after valve is in place.	If packing is damaged, reinstall oil valve with new packing: if packing is not damaged install new valve (with new packing).

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
B. Low Oil Pressure (Continued)		
(4) Defective Main Oil Pump	(a) Drain oil. (b) Remove main oil pump (Section 72-0). (c) Inspect pump packings for damage. NOTE: Check pump cavity in gearbox for scoring. (d) Refill oil tank after pump is in place.	If packings are damaged, reinstall old pump with new packings; if packings are not damaged, install new pump (with new packings).
C. High Oil Pressure		
(1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual. NOTE: On airframe installations in which main oil pressure is read directly (cockpit gage vented to ambient rather than to engine gearbox), increase in breather pressure will result in equal increase in main oil pressure indication. See breather pressure check under "Excessive Oil Consumption".	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
(2) Defective Oil Pressure Relief Valve	(a) Drain oil. (b) Remove oil pressure relief valve (Section 72-00). (c) Check preformed packing for damage. NOTE: If packing is undamaged and valve is suspect, inspect old valve for internal binding per (Section 72-00) General Maintenance Procedures. (d) Refill oil tank after valve is in place.	If packing is damaged, reinstall old valve with new packing; if packing is not damaged, install new valve (with new packing).
D. Fluctuating Oil Pressure		
(1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
(2) Defective Oil Pressure Relief Valve	(a) Drain oil. (b) Remove oil pressure relief valve (Section 72-0). (c) Check preformed packing for damage. NOTE: If packing is undamaged and valve is suspect, inspect old valve for internal binding (Section 72-0). (d) Refill oil tank after valve is in place.	If packing is damaged, reinstall old valve with new packing; if packing is not damaged, install new valve (with new packing).

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
E. Oil Pressure Following Throttle		
Defective Oil Pressure Relief Valve	(a) Drain oil. (b) Replace oil pressure relief valve (Section 72-0). NOTE: Inspect removed oil pressure relief valve for internal binding (Section 72-0). (c) Refil oil tank after valve is in place.	Replace oil pressure relief valve.

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
F. Oil Filter Differential - Pressure Signal Does Not Go Out		
(1) Defective Airframe/QEC Indication	See applicable airframe maintenance manual.	
(2) Clogged Main Oil Filter	NOTE: Disassemble and clean removed oil filter (Section 72-0).	Replace main oil filter (Section 72-0).
G. High Oil Temperature Indication		
NOTE: If oil temperature exceeds maximum steady state temperature limit of 270°F (132°C) for more than 15 minutes. Refer to "Oil Temperature Over Limit" chart in Oil Systems Section 79.		
(1) Low Oil Quantity	Check oil level.	Add oil.
(2) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
(3) Fuel De-Icing Valve Stuck Open	(a) Start engine and stabilize at idle. (b) Advance power lever to 1.6 EPR. (c) Activate fuel de-icing valve and fuel temperature should increase 70°F to 110°F (39°C to 61°C) within one minute. (d) Return engine to idle and shut down.	If no change, replace fuel de-icing valve (Section 73-8-1).
(4) Fuel/Oil Cooler Bypass Valve Open	Remove fuel/oil cooler (Section 79-1-1).	Clean oil cooler element or replace cooler (Section 79-1-1)

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
G. High Oil Temperature Indication (Continued)		
(5) Bearing Failure	(a) Remove main oil strainer per (Section 72-0).	
	(b) Disassemble main oil strainer and check for metal particles.	
	(c) Check chip detectors (if engine is so equipped).	Replace engine if metal particles are found.
	(d) Sample engine oil to determine whether or not oil is black.	Replace engine if oil is black.
	(e) Perform breather pressure check (see "Excessive Oil Consumption" in this section).	
H. Excessive Oil Consumption		
(1) External Tubing Leakage	Inspect oil pressure, breather, and scavenge tubes for evidence of leakage.	Replace tube connector seals and torque connectors.
(2) Oil Discharge At Overboard Breather	NOTE: Check engine log for evidence of oil system overservicing (unnecessary oil addition).	
	(a) Install locally-manufactured oil tank cap with 0 - 30 psig gage attached.	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
H. Excessive Oil Consumption (Continued)		
	(b) Start engine and stabilize at idle. Accelerate to Take-off power. CAUTION: OBSERVE PROPER SAFETY PRECAUTIONS AROUND RUNNING ENGINE. USE TELLTALE GAGE OR LARGE DIAL GAGE FOR EASY READING IF POSSIBLE. WIRE ALL TEST INSTRUMENTS SECURELY TO PREVENT DAMAGE BY VIBRATION. (c) Observe and record breather pressure. (d) Return engine to idle and shut down. NOTE: Although oil consumption is used as the basis for removing an engine from service, experience has shown that it is not economical to maintain an engine in service when steady state breather pressure exceeds 7 inches of Hg. NOTE: Some operators make use of a static airflow check to determine general condition of entire engine oil and breather system. This check is performed by pressurizing oil system at oil tank to 10 psig with gearbox breather vent capped. Leakage greater than 60 pph is considered excessive but has not been established as a limit.	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
H. Excessive Oil Consumption (Continued)		
(3) Static Oil Flooding Of Gearbox	See Para. 10	

6. Air Bleed Systems

Possible Cause	Test Procedure	Corrective Action
A. Surge Bleed Not-Operable Or Off Schedule		
	Perform surge bleed valve check (Section 72-0 Engine Adjustment/Test).	If surge bleed inoperative or off schedule, perform steps 1 through 3 as necessary.
(1) PRBC Vent Screen Contamination	Inspect screens.	Clean as necessary.
(2) Defective Pt2, Ps3, or Ps4 Tubes	Inspect PRBC tubes for connector tightness, freedom from cracks or obstruction.	Retorque or replace tubes as necessary.
(3) Defective Pressure Ratio Bleed Control	If bleed valve does not function or is off-schedule and checks (1) and (2) show no defect, PRBC is faulty.	Replace PRBC (Section 75-31-1). NOTE: Ensure that replacement PRBC is calibrated to current overhaul manual schedule (Section 75-6-1).

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
B. Engine Anti-icing Bleed System Inoperative		
(1) Defective Electrical Circuit To Anti-Icing Valve	Check electrical circuit for power to anti-icing valve.	Replace defective switch or wiring to anti-icing valve.
(2) Anti-icing Air Regulator Defective	Check valve position indicator for movement.	Replace regulator.
(3) Anti-icing Air Valve Defective	Check valve position indicator for movement.	Replace valve.

7. Fuel System

Possible Cause	Test Procedure	Corrective Action
A. No Fuel Flow With Fuel Shutoff Lever On		
(1) Improper Fuel Shutoff Lever Rigging	Check for full travel at fuel control.	Re-rig as necessary.
(2) Defective Fuel Pump	(a) Connect 0 - 300 psig gage to fuel pump discharge port.	
	(b) With fuel shutoff lever in "On" position, motor engine with starter and observe fuel pressure.	If pressure is below 150 psig, replace fuel pump.
(3) Defective Fuel Control	Perform fuel pump discharge pressure check in (2).	If fuel pump output is normal, replace fuel control.
(4) No Fuel To Engine	See applicable airframe maintenance manual.	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
B. Fuel Flow Indication But No EGT Rise On Starting		
(1) Defective Fuel Pressurizing and Dump Valve	(a) Motor engine with starter and check for fuel draining from P&D valve (for valves with open drain ports only).	If fuel drains, replace P&D valve (Section 73-4-1).
	(b) Check P&D valve fuel strainer (Section 73-4-1).	Clean or replace strainer.
(2) Defective Ignition System	See Ignition System.	
C. Hung Start (No Acceleration To Idle)		
Defective Ps4 Sense Line	(a) Inspect Ps4 sense line for leaks or breaks.	Tighten or replace line as necessary.
	(b) If icing conditions are present, check for internal icing by applying external heat (flameless hot air only).	If external heat solves problem by removing icing, drain water from Ps4 sense line and water trap. Blow line clear (from fuel control end) using dry compressed air. If icing is not problem, replace fuel control.
D. Hot Start (EGT High On Starting)		
(1) Defective Fuel Control	Check for excessive starting fuel flow.	Replace fuel control.
(2) Defective Pressurizing and Dump Valve		Replace P&D valve.

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
E. Engine Unable To Attain Takeoff EPR		
(1) Improper Fuel Shutoff Lever	Check for full travel at fuel control.	Re-rig as necessary.
(2) Fuel Control Not Correctly Trimmed	Perform part power trim check. See applicable airfram maintenance manual.	Retrim fuel control.
(3) Defective Fuel Pump	(a) Connect 0 - 300 psig gage to fuel pump discharge port.	
	(b) With fuel shutoff lever in "On" position, motor engine with starter and observe fuel pressure.	If pressure is below 150 psig, replace fuel pump.
(4) Insufficient Fuel Control Ps4 Sense	Check Ps4 line for leaks.	Retorque or replace line.
(5) Defective Fuel Control	Perform fuel pump discharge pressure check in (2).	If fuel pump output is normal, replace fuel control.
(6) Insufficient Fuel To Engine	See applicable airframe maintenance manual.	
F. Throttles Out Of Alignment		
(1) Improper Power Lever Rigging	See applicable airframe maintenance manual.	
(2) Improper Trim	See applicable airframe maintenance manual.	
(3) Fuel Restriction	See applicable airframe maintenance manual.	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
G. Fuel Temperature Low With Fuel Heat On		
(1) Defective Indication System	See applicable airframe maintenance manual.	
(2) Fuel De-Icing Shutoff Valve Failed Closed	Check position of shutoff valve indicator if applicable.	Replace shutoff valve.
(3) Defective Fuel De-icing Heater	Remove fuel de-icing heater and check for obstruction.	Replace fuel de-icing heater.
(4) Failed Fuel Pump Impeller (Boost Stage)		Replace fuel pump.

8. Engine Indicating System

Possible Cause	Test Procedure	Corrective Action
A. Engine Pressure Ratio System Inoperative		
Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
B. Engine Pressure Ratio Indication Fluctuates		
Loose Pt2 Line Connections	Check Pt2 connections, (see applicable airframe maintenance manual).	Retorque or replace tubes as necessary.
C. Engine Pressure Ratio Indication Drops Excessively When Anti-Icing Air Is Used		
Loose Pt2 Line Connections	Check Pt2 connections, (see applicable airframe maintenance manual).	Retorque or replace tubes as necessary.

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
D. Low Engine Pressure Ratio (EGT Redline Reached Before Engine Reaches Required EPR)		
(1) Defective Airframe/QEC EPR Indication System	See applicable airframe maintenance manual.	
(2) Defective EGT Indicating System	See (Section 77-1-2).	
(3) Leaking Pt7 System	Check Pt7 fittings for looseness. Leak check Pt7 System (Section 77-2-0).	Torque loose fittings.
(4) Obstructed Airframe/QEC Pt7 Line	Disconnect line and check for obstructions (see applicable airframe maintenance manual).	
(5) Obstructed Pt7 Probes or Manifold	(a) Disconnect Pt7 outer internal tube connector and connect a source of clean filtered air (or bottled nitrogen) into Pt7 mainfold, regulated to 10 psig.	
	(b) Pass hand in front of each Pt7 probe and check for even air discharge from probe holes.	If blockage is found, clean or replace probes.
E. No N1 Or N2 Indication		
(1) Compressor or Turbine Rotors Seized or Jammed	(a) Check inlet and tailpipe areas for damage.	Replace engine if damage is found.
	(b) Check N1 and N2 rotors for freedom of rotation. (Section 72-0)	If N1 or N2 rotor does not rotate, replace engine.

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
E. No N1 Or N2 Indication (Continued)		
(2) Defective Indication System	Check connections to tach generator and cockpit gage.	If no discrepancies found, replace tach generator or gage.
F. N1 Or N2 Indication Fluctuates		
Defective Indication System	Check connections to tach generator and cockpit gage.	If no discrepancies found, replace tach generator or gage.
G. Exhaust Gas Temperature System Inoperative (No EGT Indication)		
(1) Defective Airframe/QEC Indication System	See applicable air-frame maintenance manual.	
(2) High Resistance in EGT Averaging Leads	Perform continuity and resistance check. (Section 77-1-1)	Replace cable or leads as necessary.
H. EGT Indication High Compared To EPR, N1, And N2		
(1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
(2) Defective EGT Probes	Perform continuity and resistance check. (Section 77-1-1)	Replace suspect probes or leads.
I. EGT Indication Low Compared To EPR, N1, And N2		
(1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
(2) Defective EGT Probes	Perform continuity and resistance check. (Section 77-1-1).	Replace suspect probes or leads.

ENGINE - TROUBLESHOOTING

9. Ignition System

Possible Cause	Test Procedure	Corrective Action
A. Ignition System Inoperative		
(1) No Power Input to Ignition Exciter	See applicable airframe maintenance manual.	
(2) Defective Igniter Plug	WARNING: TAKE PRECAUTIONS TO AVOID PERSONAL INJURY WHILE CONDUCTING FUNCTIONAL CHECKS ON IGNITER PLUGS. MAKE SURE EXCITER ENERGY IS COMPLETELY DISCHARGED BEFORE HANDLING IGNITION LEADS, AND PERFORM "CLEAR ENGINE PROCEDURE" IN SECTION 72-0, ADJUSTMENT/TEST TO CLEAR FUEL VAPOR FROM ENGINE. WARNING: BECAUSE THE VOLTAGE AT THE IGNITER PLUGS IS DANGEROUSLY HIGH, THE IGNITION SWITCH MUST BE IN "OFF" POSITION, AND THE IGNITION SYSTEM INOPERATIVE FOR SIX MINUTES BEFORE THE REMOVAL OF IGNITION SYSTEM COMPONENTS. FOR ADDITIONAL PROTECTION AGAINST ELECTRICAL SHOCK HAZARD, AFTER DETACHING THE IGNITER PLUG COUPLING NUTS TOUCH THE CONNECTOR CONTACT TO THE IGNITER PLUG BODY SHIELD. THIS IS TO ENSURE THE COMPLETE DISSIPATION OF ENERGY.	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
A. Ignition System Inoperative (Continued)		
	(a) Remove igniter plugs (see Section 74-6-1). Using an auxiliary 20 joule ignition exciter, check igniter plug operation. (Section 74-6-1).	Replace defective igniter plug (Section 74-6-1).
(3) Defective Igniter Plug Lead	WARNING: TAKE PRECAUTIONS TO AVOID PERSONAL INJURY WHILE CONDUCTING FUNCTIONAL CHECKS ON IGNITER PLUGS. MAKE SURE EXCITER ENERGY IS COMPLETELY DISCHARGED BEFORE HANDLING IGNITION LEADS, AND PERFORM "CLEAR ENGINE PROCEDURE" IN SECTION 72-0, ADJUSTMENT/TEST TO CLEAR FUEL VAPOR FROM ENGINE. WARNING: BECAUSE THE VOLTAGE AT THE IGNITER PLUGS IS DANGEROUSLY HIGH, THE IGNITION SWITCH MUST BE IN "OFF" POSITION, AND THE IGNITION SYSTEM INOPERATIVE FOR SIX MINUTES BEFORE THE REMOVAL OF IGNITION SYSTEM COMPONENTS. FOR ADDITIONAL PROTECTION AGAINST ELECTRICAL SHOCK HAZARD, AFTER DETACHING THE IGNITER PLUG COUPLING NUTS, TOUCH THE CONNECTOR CONTACT TO THE IGNITER PLUG BODY SHIELD. THIS IS TO ENSURE THE COMPLETE DISSIPATION OF ENERGY.	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
A. Ignition System Inoperative (Continued)		
	(a) Remove igniter plugs. Ensure that igniter plugs are operating correctly. See Item (2).	
	(b) Reconnect plugs to leads outside engine and activate ignition system from cockpit. Observe spark intensity and firing rate.	Replace defective plug leads.
(4) Defective Ignition Exciter	Perform Items (1) through (3).	If items (1) through (3) fail to correct problem, replace ignition exciter and/or transformer. (Section 74-1-0).

10. Static Oil Flooding Of The Gearbox

See Figure 101.

A. Static leakage of oil from the tank to the gearbox can occur as a result of oil leakage past seals and valve seats located at the main strainer assembly, oil pressure relief valve, and main oil pump which are intended to retain oil against the pressure exerted by the head of oil in the oil tank. Normally, static leakage will not be a problem if it occurs at a slow rate. However, the rate of leakage can be rapid and as oil drains from the tank it floods the gearbox and drains overboard through the gearbox breather vent. This overflow provides an external indication of the problem. Overboard drainage which is detected only after extended periods of engine shutdown will, in most instances, not be a problem when the engine is operating.

B. When the engine is not running, oil at the pump inlet and at the relief side of the oil pressure relief valve is under gravity pressure from the oil tank. This oil can flow through the pump gears and through the external tube to the main oil strainer assembly where it is blocked by the strainer bypass valve and by the check valve downstream of the strainer element. If leakage occurs at these locations or at the oil pressure relief valve area, oil will pass through the gearbox jets into the gearbox. If static leakage occurs at the main oil pump shaft lip seals or at the pump center and inboard O.D. "O" ring packings, oil will leak into the gearbox.

ENGINE - TROUBLESHOOTING

C. The following troubleshooting procedure is suggested for engines having a static oil leakage problem detected by oil drainage from the gearbox overboard breather. For reference information, leakage of 946 cc per hour (16 cc/min.) amounts to approximately 3 gallons in 12 hours.

(1) Drain the gearbox and after the initial drainage surge, determine the stabilized drainage rate from the gearbox drain. An oil supply must be maintained in the oil tank for this drainage check.

(2) With the gearbox drain still open, remove the strainer element assembly from the strainer housing. Oil from the tank will leak from the strainer cavity as a result of oil flow through the pump gears. Recheck the drainage rate from the gearbox drain. If leakage from the drain continues at the previous rate, leakage is at the pressure relief valve or at the main oil pump. If leakage from the drain stops, the leakage area is in the strainer assembly.

The above check can also be accomplished by removing the gearbox oil out-to strainer tube assembly and installing a cover on the gearbox oil outlet port. This will prevent oil drainage resulting from leakage through the pump gears.

(3) If the problem is determined to be in the strainer assembly, see Figure 102 and proceed as follows:

(a) Remove the strainer check valve using PWA 30491 Puller. Check the following and correct discrepancies as necessary:

1 Condition of packings, Indexes 1 and 2.

2 Condition of lower disk and valve seat, Indexes 3 and 4.

3 Possible binding of valve rod in the seat sleeve, Indexes 5 and 4.

4 Possible weak spring, Index 6.

5 Condition of strainer housing cavity surface where valve assembly packing, Index 2, seats.

(b) Remove the bypass valve liner, springs, valve, and valve seat. Bypass valve and seat can be removed by pushing from inside the strainer housing. Check the following and correct discrepancies as necessary:

1 Condition of packing, Index 7.

2 Condition of the valve and mating seat, Indexes 8 and 9.

3 Possible binding of the valve in the valve liner, Indexes 8 and 10.

ENGINE - TROUBLESHOOTING

4 Possible weak springs, Index 11.

5 Condition of inner surface where packing, Index 7, seats.

(4) If check step (2) above indicates that the problem is in the pressure relief valve or oil pump, proceed as follows:

(a) Oil Pressure Relief Valve. See Figure 103.

1 Drain the oil from the oil tank.

2 Remove valve parts and using PWA 16359 Puller remove the valve seat from the gearbox housing.

3 Check the following and correct discrepancies as necessary:

a Condition of packing, Index 1.

b Condition of the valve sealing surface and mating seat surface, Indexes 2 and 3.

c Possible binding of the valve in the valve housing, Indexes 2 and 4.

d Possible weak springs or worn spring seat, Indexes 5 and 6.

e Condition of internal gearbox surface where packing, Index 1, seats.

(b) Oil Pressure Pump, See Figure 104.

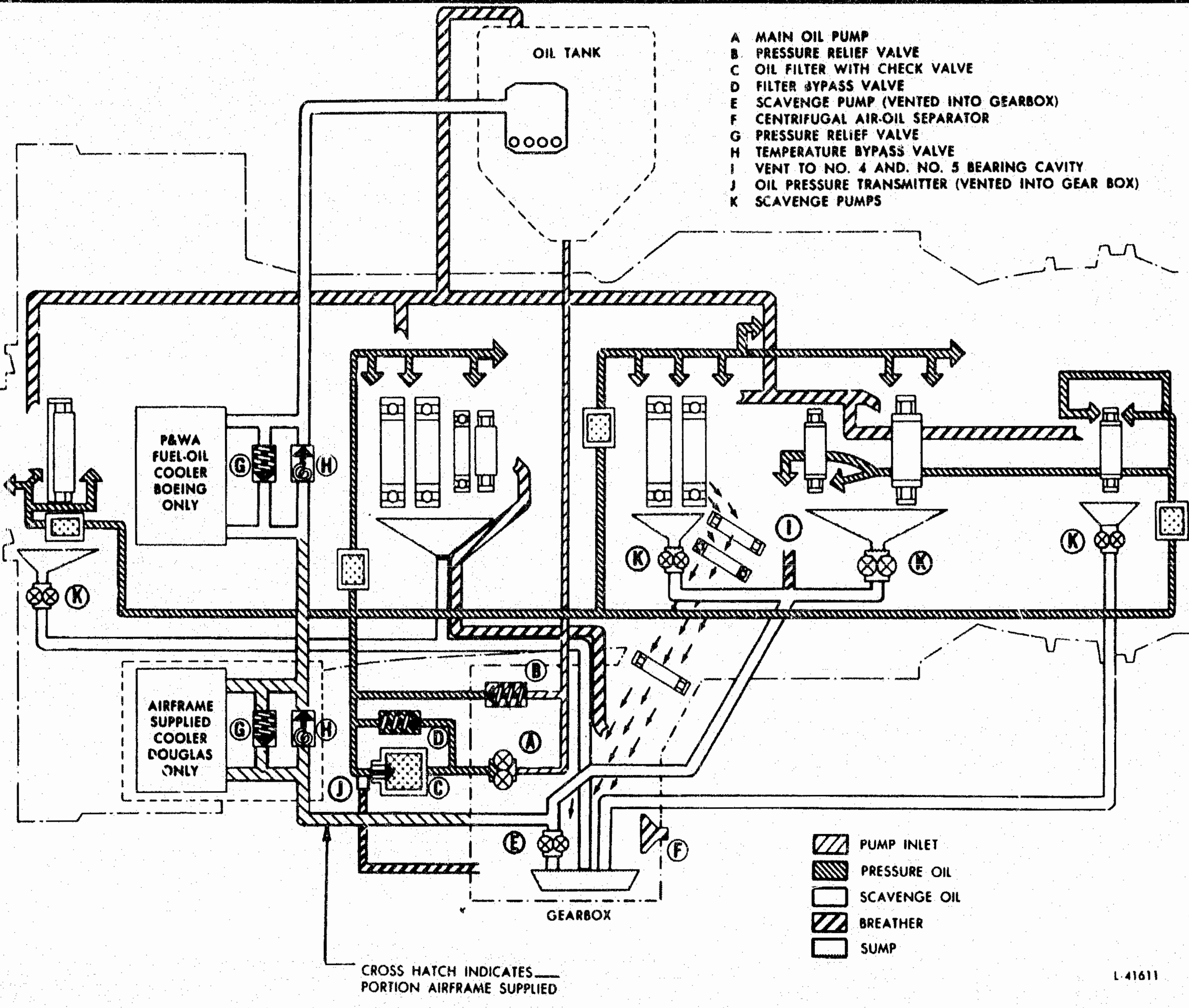
1 With the oil tank drained, remove the pump assembly using two PWA 2536 Pullers.

2 Check the following and correct discrepancies as necessary:

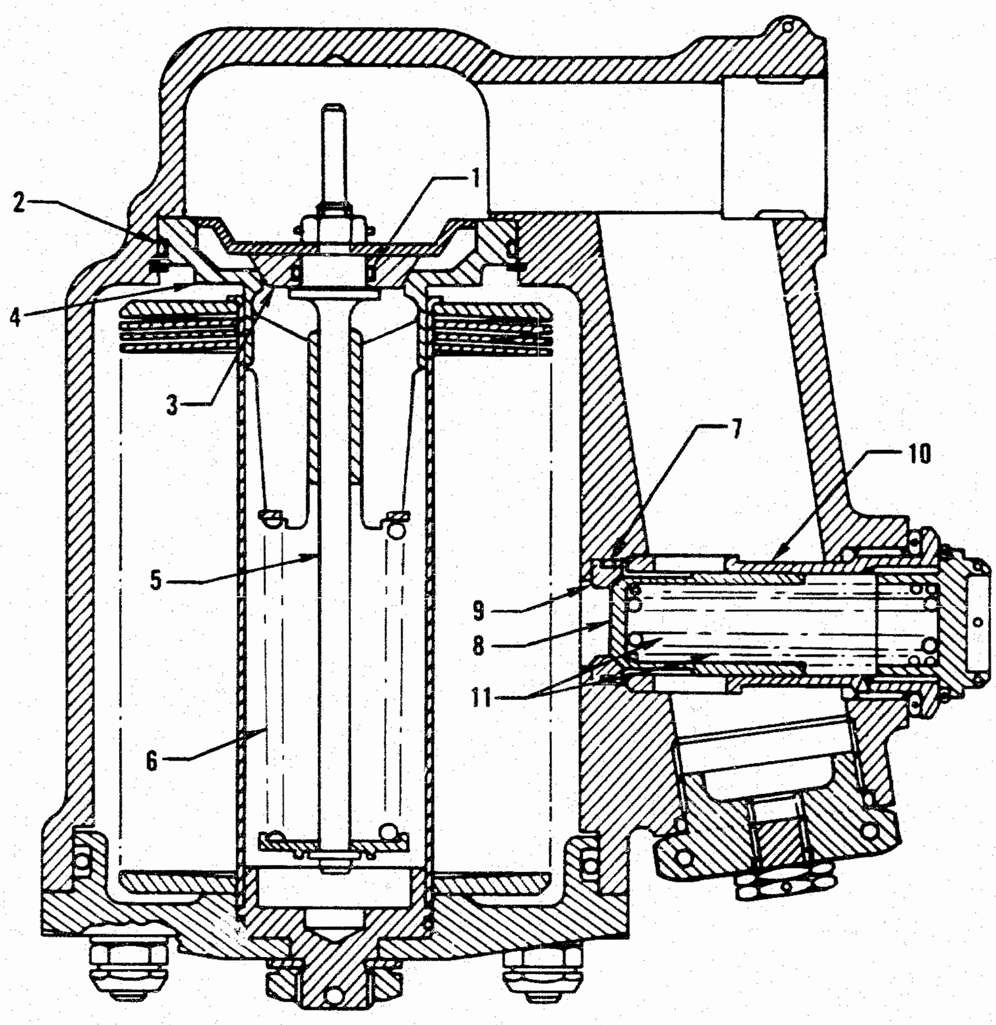
a Condition of the center and inner O.D. packings, Indexes 1 and 2. A problem with the outer O.D. packing will result in external leakage.

b Condition of the two lip seals and mating gearshaft journals, Indexes 3 and 4.

c Condition of gearbox internal surfaces that mate with the center and inner packings.



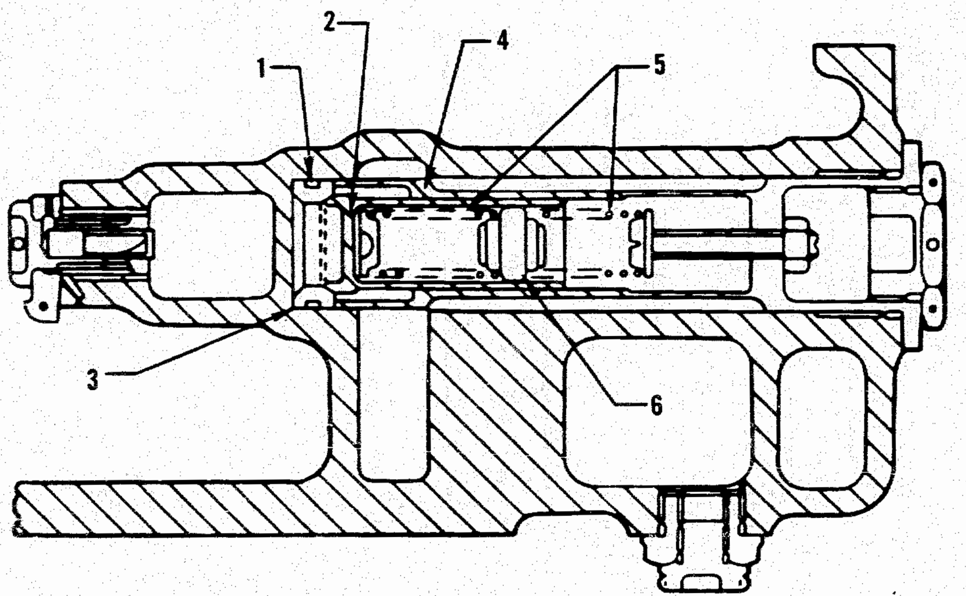
Lubrication System Schematic
Figure 101



1. Packing
2. Packing
3. Lower Disk
4. Check Valve Seat
5. Valve Rod
6. Check Valve Spring
7. Packing
8. Bypass Valve
9. Bypass Valve Seat
10. Bypass Valve Liner
11. Bypass Valve Springs

Filter Housing Assembly
Figure 102

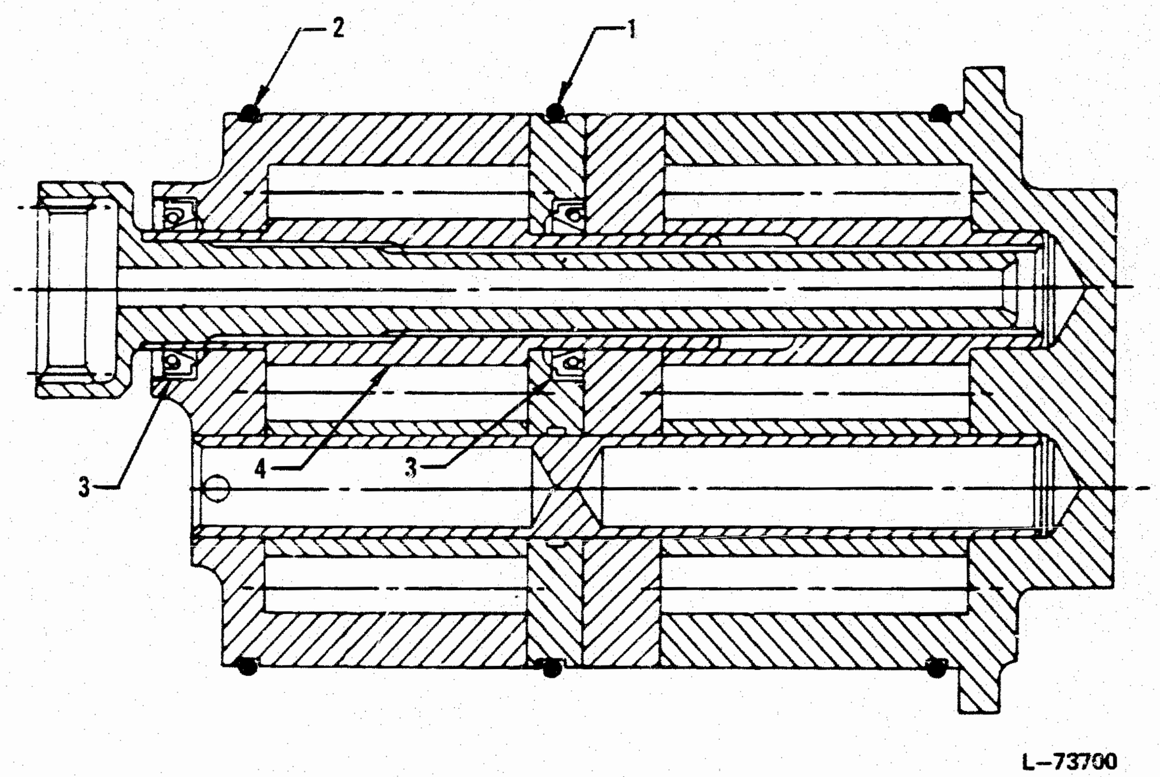
ENGINE - TROUBLESHOOTING



1. Packing
2. Valve
3. Valve Seat
4. Valve Housing
5. Spring
6. Spring Seat

Cross Section Of Main Oil Pressure
Relief Valve As Installed In Engine
Figure 103

ENGINE - TROUBLESHOOTING



1. Center O. D. "O" Ring Packing
2. Inner O. D. "O" Ring Packing
3. Shaft Lip Seal
4. Gearshaft

Oil Pump Assembly
Figure 104

ENGINE - SERVICING

1. Periodic Inspection

(1) The life of the engine and its associated equipment is determined by operational conditions. The inspection system must anticipate these conditions. See Inspection/Check for periodic inspection procedures.

2. Repair

(1) The permissible repair procedures for line maintenance are listed in Approved Repairs. These repairs can be made at any airport.

3. Fuel

A. General

(1) The fuel for the engine shall conform to PWA-522 Specifications.

(2) Fuel contamination may occur in shipment, during transfer from one container to another, or in the aircraft fuel system from scale, lint from packings and seals, and deterioration of fuel lines and hoses. Serious malfunction of the engine will occur, even to the extent of engine stoppage, as a result of contaminants in the fuel reaching the engine fuel system. It is important, that the mesh screen in the aircraft fuel system upstream of the engine fuel pump be inspected periodically for removal of all foreign particles.

B. Fuel Drainage

See Section 72-0, Adjustment/Test.

4. Fuel Tanks

See Chapter 28.

5. Oil

A. General

(1) The synthetic oil for the engine shall conform to PWA-521 Specifications.

(2) The engine internal oil system is shown schematically in Figure 48.

B. Oil Connections and Servicing Drains

(1) The oil connections are separated into two groups; overboard drains and operational connections. The servicing drains are not aircraft oil connections but are used to drain oil from engine low points.

6. Storage of the Shipping Container

A. Remove the humidity indicator from the observation port and remove the dehydrating agent from the bottom of the sealing cover. Place all the internal components, bolts, nuts, side rails, and brackets in the container. Secure these units and then secure the container side sections and cover for storage.

7. Preservation/Depreservation of the Engine

CAUTION: ENGINES AWAITING REPAIR OR OVERHAUL SHALL HAVE ADEQUATE PRESERVATION MEASURES ACCOMPLISHED. UPON REMOVAL FROM AIRCRAFT, ENGINES SHUT DOWN OR NOT OPERATED IN FLIGHT SHALL BE DRIED ACCORDING TO PROCEDURES FOR SPARE ENGINE TRANSPORTATION AND STORAGE.

NOTE: Engine storage situations not specifically covered shall be preserved by practices and procedures compatable with preservation principles of this manual.

A. The procedure to be followed in the preservation and depreservation (reactivation) of engines in service will vary depending upon the length of inactivity, the type of preservative used, and whether or not the engine may be rotated during the inactive period. Therefore, before attempting work of this nature, refer to the preservation records (tags) and the engine service record (log book) and also establish the length of inactivity or length of inactivity anticipated.

B. Engine Preservation Schedule

CAUTION: UNDER NO CIRCUMSTANCES SHALL PRESERVATIVE OIL BE SPRAYED INTO THE COMPRESSOR OR TURBINE END OF THE ENGINE. DIRT PARTICLES DEPOSITING ON THE BLADES AND VANES DURING OPERATION WILL ALTER THE AIRFOIL SHAPE AND ADVERSELY AFFECT COMPRESSOR EFFICIENCY.

(1) 0 to 7 days. Engines may be left in an inactive status with no preservation protective requirements provided:

(a) The engine is sheltered.

ENGINE SERVICING

(b) Humidity is not excessively high.

(c) The engine is not subjected to extreme temperature changes which would produce condensation.

(2) 7 to 28 days. Engines which are to be inactive up to 28 days may have no preservation providing all engine openings are sealed off and the relative humidity in the engine is maintained at less than 40 percent. This can be accomplished by placing approximately 26 pounds of dehydrating agent in the engine inlet and the tailpipe. Place the dehydrating agent on racks to keep it off engine parts. Suitable windows shall be provided in the inlet and the exhaust closures to allow observation of the humidity indicators.

(3) 28 to 90 days. Engines which are to be stored longer than 28 days but not to exceed 90 days need only the fuel system preserved. The engine oil system shall be drained; however no oil system preservation is required. Desiccant agents, humidity indicators, engine coverings such as intake, exhaust breather discharge, etc. must be utilized.

(4) 90 plus days. Engine preservation must be complete. Preserve the engine oil system and the engine fuel system as described in the following paragraphs.

C. Engine Oil System Preservation

(1) The following procedures shall be followed for the preservation of engines which are to be inactive for periods exceeding 90 days.

(a) Rotate the engine with the starter or auxiliary power unit at the starter pad until oil pressure and high compressor (N_2) speed is indicated. Disengage starter.

(b) Open the drain on the bottom of the oil tank and remove the drain plug from the bottom of the N_2 gearbox. Drain all oil into suitable containers.

(c) With the drains open, motor the engine over to 1200 plus or minus 100 rpm with the starter, allowing the scavenge pumps to clear the engine, indicated by a cessation of a steady stream of oil from the drains. To prevent excessive operation with limited lubrication, limit the rotation to the shortest possible time to fulfill the above requirement. Starter operating time limits should not be exceeded.

(d) Remove the main oil strainer and rinse the assembly in petroleum solvent.

(e) Allow the engine oil to drain to a slow drip for approximately one-half hour.

(f) Install oil strainer and close previously opened drains.

(g) Fill oil tank with new engine oil.

(h) Motor engine over with starter until oil pressure indication is observed.

(i) Start and operate engine for five minutes at 75 percent normal rated and shut down engine. Specific engine operating instructions should be observed during preservation run.

(j) Drain oil tank and accessory case by opening oil tank drain and removing drain plug from bottom of N_2 gearbox. Drain oil into suitable containers.

(k) Close oil tank drain and reinstall N_2 gearbox drain plug.

(l) Remove cover plates from pads of accessory drives upon which accessories are not installed and spray exposed surfaces with engine oil. Reinstall cover plates.

(m) Plugs, caps, covers, or screens should be installed over all openings to prohibit entrance of foreign material and accumulation of moisture.

(n) If engine is to remain in aircraft, install 52 pounds of dehydrating agent, distributing 26 pounds in compartment. The balance should be distributed equally in aircraft inlet and exhaust section.

(o) Oil filler caps should be tagged as to preservative used and date of preservation. Using an air tight moisture barrier or other suitable covers, cover air inlet and exhaust end of engine compartment, installing humidity indicator at each end. Inspection windows at each end should be provided through which indicators will be visible.

(p) Inspection of preserved unit should be made every two weeks if aircraft is stored outside or every 30 days if aircraft is stored inside. If relative humidity as indicated on humidity cards is 40 percent or less, no further action is required. If humidity indications are 40 percent or higher, unit should be depreserved, then represerved.

D. Fuel System Preservation

NOTE: On engines modified by SB 3721, dump valve overboard drain and signal lines have been removed and ports plugged. In order to perform fuel system preservation on these engines, remove plugs from dump valve overboard drain and signal ports and disregard step (2).

(1) Place suitable container, having minimum capacity of five gallons, under pressurizing and dump valve overboard drain.

ENGINE - SERVICING

(2) Disconnect dump signal line (line from pressurizing and dump valve to fuel control) at either end. Install pressure tight closure on passage leading to fuel control, leaving passage to dump valve open to atmosphere.

(3) Disconnect fuel-in supply at inlet pad of fuel pump and connect supply of filtered slushing oil at pressure of 5 to 25 psi and minimum temperature of 60°F (15°C). Extreme care should be taken to prevent foreign material from being drawn into engine fuel system. Equipment should be provided with suitable filters and/or strainers of no coarser mesh than used in engine. Ten micron filter is recommended for this purpose.

(4) With ignition switch off and fuel control shut-off lever open, move fuel control power lever to full open position. Motor engine at a speed of 1700 ± 100 rpm with starter until at least two gallons of oil have discharged out overboard drain. During motoring period fuel control power lever should be moved from open to closed to open.

(5) Remove closure from dump signal passage leading to fuel control and reinstall line to pressurizing and dump valve fitting.

NOTE: On engines modified by SB 3721, reinstall plugs in dump valve overboard drain and signal ports.

(6) Fuel control power lever should be tagged as to preservative used and date of preservations.

E. Preservation of the Water Injection System

(1) Attach source of heated dehydrated air to water inlet pad. Actuate water shut-off valve to open position.

(2) Allow heated air at temperature not to exceed 250°F (121°C) to blow through system for minimum of ten minutes.

(3) On completion of procedure, return shut-off valve to closed position.

F. Engine Depreservation Schedule

(1) 0 to 28 days. No depreservation required.

(2) 28 to 90 days. Depreserve fuel system and service engine oil system with fresh oil.

(3) 90 plus days. Complete depreservation is required.

ENGINE - SERVICING

G. Engine Depreservation

NOTE: On engines modified by SB 3721, dump valve overboard drain and signal lines have been removed and ports plugged. In order to perform fuel system depreservation on these engines, remove plugs from dump valve overboard drain and signal ports and disregard step (5).

Check all oil passages for obstructions before installing accessories which are dependent on engine oil.

(1) Remove all moisture barriers, humidity indicators, and dehydrating agent.

(2) Fill oil tank with engine lubricating oil.

(3) Connect fuel supply line to fuel inlet pad.

(4) Place suitable container, having minimum capacity of five gallons, under pressurizing and dump valve overboard drain.

(5) Disconnect either end of dump signal line-to-fuel control tube. Leave dump valve connection open to atmosphere. Plug fuel control connection with suitable plugged fitting to prevent dumping of fuel.

CAUTION: ROTATION OF ENGINE SHOULD BE LIMITED TO SHORTEST POSSIBLE TIME IN ORDER NOT TO EXCEED STARTER OPERATING LIMIT.

(6) With ignition off, fuel control shut-off lever open, and fuel control power lever in full open position, motor engine over with starter on external power source to high rotor (N_2) speed of 1700 $\pm$ 100 rpm. During motoring period, fuel control power lever should be moved from open to closed to open.

(7) When at least two gallons of fluid have been obtained from overboard drain, close fuel control lever, and disengage starter.

(8) Remove plugged fitting from dump signal line and reconnect signal line to pressurizing and dump valve.

NOTE: On engines modified by SB 3721, reinstall plugs in dump valve overboard drain and signal ports.

(9) Remove preservation tags and make proper entry in engine records.

8. Inspection of Engine During Storage

A. Maintenance

(1) Maintaining engine during storage period consists principally in maintaining air within container below 40 percent relative humidity. Although experience and tests indicate that corrosion will not usually occur at relative humidities below 40 percent, corrosion is occasionally found even though record indicated that safe level has not been exceeded. Usually, this corrosion has been shown to result from renewal of dehydrating agent being delayed too long. Maintenance procedure for an engine in storage is as equally important as initial preservative treatment. Only when the two are carried out in every detail can there be assurance of protection to engine during the storage period.

ENGINE SERVICING

B. High Relative Humidity Indication of Engines in Storage

(1) If the humidity indicator shows the relative humidity within the container to exceed 40 percent, proceed as follows:

(a) Position the container under a suitable hoist. A free overhead space of approximately eight feet minimum, exclusive of the distance from the top of the container to the hoist hook, is required.

(b) After removing the straps, install a suitable sling to the rings in the top section of the container.

(c) Unfasten the four hooks securing the side sections of the container.

(d) Raise the top section straight up until free and clear of the engine and draw it to one side; then remove the four side sections.

(e) Using a knife, open the covering and check it for tears or holes.

(f) Check the engine for evidence of corrosion.

(g) Remove the old humidity indicator from the observation port and the dehydrating containers from the bottom of the covering.

NOTE: Care must be exercised to assure that the dehydrating agent and humidity indicator which have been removed are properly disposed of and cannot possibly be reinstalled in the container.

(h) Check the interior of the container to be sure that it is free of all dirt, oil, water, or other foreign matter.

(i) Install a new humidity indicator in the place provided (observation port). Fasten the indicator securely with the tape as required so that the transparent side is visible from the exterior of the container.

(j) Place the dehydrating agent containers loosely in the bottom of the engine covering.

(k) Close the covering and seal it with a sealing iron or equivalent.

(l) Using the guide pins, install the four sides in their position on the box and fasten the four hooks. Lower the top on the container.

NOTE: If the engine is to be shipped, install the side straps.

ENGINE - SERVICING

9. Preservation of Non-Operable Engines

(1) Engines which cannot be operated or cannot use the methods described in Preservation/Depreservation shall be preserved by practices and procedures compatable with preservation principles of this manual.

10. Protection of Non-Running Engines

(1) Engines in aircraft left standing outside or exposed to the wind must have the inlet and exhaust duct openings covered, to prevent dirt, dust, and foreign materials from entering the engine, and to prevent reverse rotation of the low rotor due to wind blowing through the inlet or exhaust ducts.

11. Spare Engine Transportation and Storage

(1) A spare engine may be transported in an external pod or in a cargo compartment of an aircraft. In either case protect engine from corrosion, especially if humid conditions are expected to be encountered enroute to destination.

(2) Preserve engine, fuel and oil system, as directed in Preservation/ Depreservation of Engine.

NOTE: In addition to following regular preservation procedures the following may be done for engines which are enroute to overhaul.

CAUTION: ENGINES WHICH HAVE BEEN SPRAYED WITH OIL INTERNALLY ARE NOT TO BE RUN UNTIL COMPLETELY DISASSEMBLED AND CLEANED.

(a) While rotating both compressor and turbine rotors with the starter, use a fine spray to apply a thin film of oil on internal parts of the engine.

(b) Direct the spray into the inlet at the start and spray the exhaust area just before the rotors stop.

(3) Install fifty-two pounds of desiccant or dehydrating agent, half in the inlet and half in the exhaust section of the engine. Be sure desiccant is properly packaged and secured.

(4) Install and secure a humidity indicator in the inlet and exhaust ends of engine.

ENGINE - SERVICING

(5) Install appropriate external pod fairings and covers to act as moisture barriers and prevent air circulation through engine.

(6) Engines shipped in cargo compartments shall be wrapped in nearly air tight suitable plastic type envelope or sealed by covers at inlet and exhaust openings.

(7) Upon arrival at destination and removal of engine from aircraft remove fairings, covers, humidity indicators and dehydrating agent. Check humidity indicators before removal.

(8) Blow hot dry air through engine to remove moisture before continued storage. Hot air velocity shall not be great enough to cause engine rotations.

NOTE: If engine is to be installed in aircraft and run immediately, drying process is not required.

(9) Continued storage shall follow established procedures.

12. Transporting Engine Using "Three-Engine Ferry" Method

A. Front and rear compressor sections, of engines being transported by "three-engine ferry", must be immobilized to prevent rotation due to air passing through engine.

NOTE: Special preparation of thrust reverser or other engine related equipment may be necessary on some installations. See applicable aircraft manual.

(1) Secure front compressor rotor using three PWA 30233 Locking Straps. See Figure 301.

(a) Feed one end of strap into engine inboard of mid-span shroud, around trailing edge of 1st stage fan blade and back outside of engine.

(b) Position strap so one end extends past leading edge of inlet guide vane approximately one inch (not including velcro tape detail).

(c) Pass other (long) end of strap over leading edge of next inlet guide vane in direction of engine rotation and around trailing edge of closest first stage fan blade, causing strap to pull on blade in direction of rotation.

(d) Continue weaving strap alternately between blades and vanes keeping strap tight and always pulling compressor rotor in direction of engine rotation.

NOTE: Some blades will be skipped because there are more blades than vanes. Each strap should pass around approximately one third of the vanes.

(e) When end of strap is reached, bring end out of engine, pull tight and overlap velero tape at each end of strap.

(f) Secure velero tape by tightly rolling overlap and whipping with nylon cord for 3 to 4 inches at each end. Wrap nylon cord and velero tape with adhesive tape and tape overlaid strap span to nearest inlet guide vanes.

(g) Continue to secure remaining portions of front compressor rotor by repeating above procedure with remaining two straps.

(2) Secure rear compressor rotor using PWA-30251 Lock.

(a) Remove starter from engine (see appropriate section in airframe manual).

(b) Place PWA-30251 Lock over studs on starter drive pad engaging lock with starter drivegear splines.

(c) Secure lock to starter drive pad studs with nuts.

13. Identification of Metal Particles

A. When unidentified particles of metal are found, they may be either steel, tin, aluminum, magnesium, silver, bronze, or cadmium. In some cases the type of metal may be determined by the color and hardness of the pieces. However, when the particles cannot be positively identified by visual inspection and knowledge of the exact character of the metal is desired as an aid to troubleshooting, a few simple tests will determine the kind of metal present.

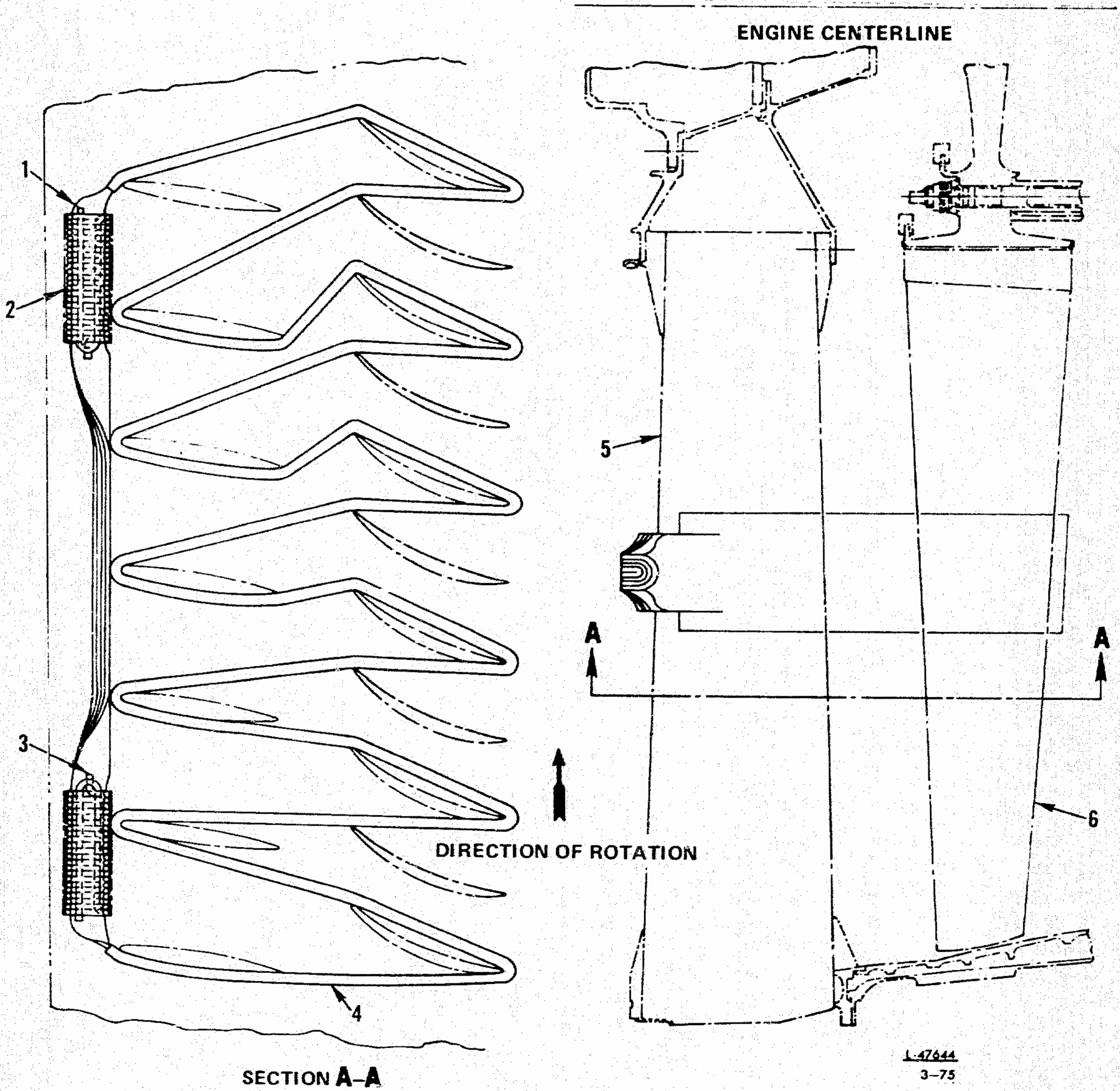
B. The following equipment and chemicals are required to make these tests: A source of open flame, a permanent magnet, two ounces of aqueous solution containing ten percent ammonium nitrate, an electric soldering iron, two ounces each of 50 percent by volume hydrochloric acid, and concentrated nitric acid, sodium hydroxide pellets, a watch glass, a white porcelain spot plate, ammonium bifluoride crystals, 5 to 10% hydrofluoric acid or concentrated sulfuric acid, 3 to 10% hydrogen peroxide, and concentrated phosphoric acid.

WARNING: USE EXTREME CARE IN HANDLING THE ACIDS.

14. Test Procedure for Identification of Metal Particles

NOTE: The following test procedure is recommended for determining the character of unknown metal particles. For best results, follow the steps as outlined:

ENGINE - SERVICING



1. Nylon Cord Wrap, Two Places. Reference Tool Detail-4.
2. Pressure Sensitive, Waterproof, Adhesive Tape Wrap, Two Places.
3. Pull Cord Tight
4. Strap Cover, Reference Tool Detail-5.
5. Inlet Guide Vane, Reference
6. First Stage Compressor Blade, Reference.

Front Compressor Rotor Locking Strap

Figure 301

A. Steel - The particles can be isolated by means of the permanent magnet. Steel or iron is attracted by the magnet.

B. Magnesium - A simple test for these particles is burning. Magnesium will burn with a bright white flash.

WARNING: NEVER ATTEMPT TO BURN MORE THAN A FEW PARTICLES OF METAL SUSPECTED TO BE MAGNESIUM. MAGNESIUM POWDER OR DUST IS EXPLOSIVE.

C. Cadmium - Place the remaining particles in the aqueous (water) solution of ammonium nitrate. If all or any of the particles dissolve in this solution, they are cadmium. After this test, rinse and dry any remaining particles.

D. Tin - The tin particles can be distinguished by their low melting point. With a clean soldering iron, heated to 500°F (260°C) and tinned with 50-50 solder (50 percent tin - 50 percent lead), a tin particle dropped on the iron will melt and fuse with the solder.

E. Aluminum - When a particle of aluminum is placed in hydrochloric acid 50 percent by volume, it will fizz with rapid emission of gas bubbles and gradually disintegrate and form a black residue (aluminum chloride). Silver and bronze do not noticeably react with hydrochloric acid.

F. Aluminum Paint - Use this procedure to determine whether or not the material is aluminum silicone paint, aluminum chips, or silver particles.

WARNING: HYDROCHLORIC ACID IS DANGEROUS AND REQUIRES SPECIAL HANDLING.

(1) Make a sodium hydroxide solution by adding one pellet of sodium hydroxide to three cubic centimeters of water.

(2) Place several drops of this solution in a watch glass and drop in the suspected particles.

(a) If the particles are aluminum silicone paint, there will be a mild reaction in the form of gas bubbles and some visible gas as the particles change to sodium aluminate.

(b) If the particles are aluminum chips, the reaction will be much more active with many more gas bubbles forming and more visible gas.

(c) If the particles are silver, there will be no reaction.

G. Silver - When silver particle is placed in nitric acid, it reacts rather slowly, producing whitish fog in acid.

H. Bronze - When bronze (or copper particle is placed in nitric acid, bright green cloud is produced

15. Test Procedure for Identificaton of Titanium Particles

A. Place a piece or pieces of the metal to be identified on a white porcelain spot plate. A piece of titanium or titanium bearing metal should be placed on another spot plate to observe and verify the results obtained.

B. Add several crystals of ammonium bifluoride and 5 - 10 drops of water to the metal particles. (2 - 3 drops of a 5 - 10 percent hydrofluoric acid solution can be used instead).

C. Let stand 20 to 30 minutes, or until the solution becomes slightly discolored.

D. Add 2 - 3 drops of 1:1 sulfuric acid (1 part water to 1 part concentrated acid).

E. Let stand 20 - 30 minutes, or until solution becomes more discolored.

F. Add 3 - 4 drops of 3 - 10 percent hydrogen peroxide. Solution must not be too old.

G. If titanium is present yellowish color will develop. This yellow color will become progressively darker with time, if allowed to set.

H. Add 2 - 3 drops of concentrated phosphoric acid, and stir to discharge any color due to possible presence of iron.

I. Any light yellow to orange coloration indicates presence of titanium.

NOTE: Above chemicals are hazardous and require special handling. Solid ammonium bifluoride is crystal-line and can be conveniently stored in dry place and used as needed.

16. Extreme Weather Maintenance

A. Cold Weather Procedures

(1) General

ENGINE - SERVICING

(a) A discourse on the effects of cold weather upon turbofan engine operation is not the purpose of this publication; however, it is felt that a summary of a few of the more prevalent effects will aid in troubleshooting some of the problems arising from cold weather operations.

(b) Aviation fuels will normally contain little or no water, but the percentage of water is governed to a great extent by storage and handling conditions of the fuel. Fuel exposed to dampness or ordinary atmospheric conditions naturally contain a larger percentage of water than those kept in tightly sealed containers. This water content, under poor conditions, may average as high as several gallons in every thousand gallons of fuel.

(c) As temperatures are reduced, the solubility of water in the fuel is also markedly reduced, which results in the water separating from the fuel, seeking the lowest point in the tank, system, and/or accessory concerned and freezing there if the temperature goes low enough. Under these conditions it also will freeze in the fuel, forming tiny needle-shaped crystals which may be found impinged on the strainers, restricting fuel flow and in severe cases clogging the strainers entirely. Should this condition occur it will be evidenced by a drop in, or loss of fuel pressure to the engine. The only remedy is hot air applied to the engine and fuel system components. Refer to airframe manufacturer's recommendations for externally applied heat.

(d) Under these conditions, it is most important that all sumps, strainers, traps (burner pressure sensing line moisture trap) and filters be thoroughly inspected on all preflight checks. As long as fuel will flow freely from the drain cocks in the tank sumps and strainers it can be surmised that the system is free of ice.

(2) Additional Preflight Inspection

(a) Examine the engine inlet and exhaust section for the collection of ice. Rotational freedom of the rear turbine should be verified.

(3) Starting Engine

(a) Start the engine using the normal starting procedure.

CAUTION: IF THERE IS NO INDICATION OF OIL PRESSURE AFTER 30 SECONDS OF ENGINE OPERATION OR IF THE PRESSURE DROPS TO ZERO AFTER A FEW MINUTES OF GROUND RUNNING, STOP THE ENGINE AND INVESTIGATE.

ENGINE - DISMANTLING/ASSEMBLY

1. Air Frame Parts

A. Refer to Chapter 71, as required, for information concerning removal of airframe installed parts.

B. Alternator Drive Adapter Pad

CAUTION: THIS MOUNT PAD MAY INCORPORATE MID-GRIP TYPE HELICAL INSERTS IDENTIFIED BY THE HEXAGONAL APPEARANCE OF ONE THREAD AND BY RESISTANCE WHEN TURNING BOLT BY HAND WITH UNIFORM THREAD DRAG, WHICH LOCKS THE BOLT IN PLACE, WHEN TURNED WITH A WRENCH. GASKET MUST BE INSTALLED SO AS NOT TO OBSTRUCT OIL PASSAGE HOLES. REMOVE THE TEST PLUGS FROM THE OIL PASSAGES IN THE ALTERNATOR DRIVE ADAPTER PAD BEFORE INSTALLING THE ALTERNATOR DRIVE ADAPTER.

C. Accessory Housing Breather

CAUTION: ON BOEING ENGINES ONLY THE ROTARY BREATHER SEAL CARRIER MUST EXTEND TO THE FACE OF THE BREATHER MOUNT PAD OR INCLUDE A SPACER P/N 446978.

2. General Maintenance Procedures

NOTE: PWA 9156-51 Engine Air Inlet Cover And PWA 9156-52 Engine Turbine Exhaust Cover have been provided to prevent foreign objects from entering engine. Use these tools as required during engine maintenance.

A. To ensure proper reinstallation, tag and mark all parts, clips, and brackets as to their location.

CAUTION: IT IS POSSIBLE TO ASSEMBLE CERTAIN ENGINE PARTS IN A LOCATION OR IN OTHER MODELS OF ENGINES FOR WHICH THESE PARTS WERE NOT INTENDED. BECAUSE SUCH MIS-ASSEMBLY CAN POSSIBLY RESULT IN A FAILURE, CHECK EACH PART TO BE SURE CORRECT PART IS USED.

B. During removal of tubes or engine parts look for indications of scoring, burning or other undesirable conditions. To facilitate reinstallation observe the location of each part during removal. Tag unserviceable parts and units for investigation and possible repair.

C. Extreme care shall be taken to prevent dust, dirt, lockwire, nuts, washers, or other foreign matter from entering the engine. If at any time such items are dropped, the assembly process must stop until the dropped articles are located, even though this may require a considerable amount of time and labor. Before assembling or installing any part, be sure it is thoroughly clean. Suitable plugs, caps, and other covering shall be used to protect all openings as they are exposed.

NOTE: Dust caps used to protect open lines against contamination shall always be installed over the tube ends and not in the tube ends. Flow through the lines may be blocked off if lines are inadvertently installed with dust caps in the tube ends.

ENGINE - DISMANTLING/ASSEMBLY

D. Lockwire, lockwashers, tablocks, tabwashers, or cotterpins shall never be reused. All lockwire and cotterpins must fit snugly in their holes. Install a cotterpin so that head fits into castellation of nut, and unless otherwise specified, bend one end of pin back over stud or bolt and other end down flat against nut. Only lockwire and cotterpins made of corrosion resistant steel shall be used. Bushing plugs shall be lockwired to assembly boss or case. Do not lockwire plug to bushing.

E. Replace all gaskets, packings, and rubber parts at every removal/installation. Make sure that new nonmetallic parts to be installed (such as an oil seal) show no sign of having deteriorated in storage. If necessary, coat gasket surfaces with Gredag Lubricant to reduce possibility of gasket adhering to surfaces of mating parts.

CAUTION: BEFORE USING TOOLS WITH COVERED SURFACES, MAKE CERTAIN THAT THERE IS SUFFICIENT PROTECTIVE MATERIAL PRESENT TO PRECLUDE POSSIBILITY OF DAMAGING ENGINE PARTS:

F. In order to protect critical areas of engine parts (such as compressor and turbine disks) against scratches and nicks, tool surfaces contacting these areas must be covered with protective material.

G. If any part were coated with corrosion preventive compounds, all traces of this compound and accumulated foreign matter must be removed.

H. Tubes which incorporate a fixed ferrule and a loose nut shall have seal retaining nut at fixed ferrule end of tube tightened first.

3. Preformed Packings

CAUTION: PREFORMED PACKINGS MUST BE COATED WITH THIN FILM OF LUBRICANT PRIOR TO ASSEMBLY. THIS LUBRICATION, PLUS PROPER ASSEMBLY, WILL PREVENT DAMAGE TO PACKINGS THAT COULD CAUSE ENGINE MALFUNCTION OR FAILURE.

A. Preformed packing lubrication requirements are as follows:

Engine System	Packing Material And Specification	Lubrication Specification
Fuel	Fluorosilicone (AMS 7273)	Oil, PWA 521 Type I or II, or petrolatum, PMC 9609
Oil	Fluorocarbon (AMS 7276, 7278, 7280)	Oil, PWA 521, Type I or II
Air, water, or alcohol	Silicone (AMS 7267)	Petrolatum PMC 9609

ENGINE - DISMANTLING/ASSEMBLY

B. At all assembly operations, whenever silicone preformed packings of materials listed below are being installed, use only petrolatum (PMC 9609) or equivalent, as lubricant, applied sparingly, on packings. Colors of preformed packings which, in general, are affected are red and off-white. Ester type oils (turbine oils) must not be used.

Silicone Rubber Preformed Packings Materials Affected

AMS 3301	AMS 3305	AMS 3334	AMS 3345
AMS 3302	AMS 3315	AMS 3335	AMS 3346
AMS 3303	AMS 3320	AMS 3336	AMS 3356
AMS 3304	AMS 3332	AMS 3338	AMS 3357

4. Installation of Preformed Packing and Jamnut Type Connector (Universal Fittings)

A. Install jamnut type connectors as follows:

See Figure 401 (Sheet 1).

WARNING: FAILURE TO ACCOMPLISH INSTALLATION PER INSTRUCTIONS MAY RESULT IN SUBSEQUENT FAILURE, FIRE, EXTENSIVE DAMAGE AND LOSS OF LIFE.

(1) Coat male threads of fittings, preformed packing and backup ring with petrolatum (PMC 9609) or jet engine oil. Plastic packing requires no lubrication.

(2) Assemble nut on fitting with counterbored face toward engaging end.

WARNING: USE OF LEATHER BACKUP RINGS HAS BEEN DISCONTINUED TO PREVENT POSSIBILITY OF FUEL LEAKAGE.

(3) Work packing into nut counterbore.

(4) Install preformed packing on non-threaded annulus of fitting.

(5) Turn nut down until preformed packing is positioned in annulus firmly against threads to be installed in mating part.

(6) Install fitting into mating part, turning nut with fitting until preformed packing contacts mating part boss. This point can be determined by increasing torque. With fitting in this position and while holding nut to prevent its turning, screw fitting into mating part an additional one and one-half turns.

NOTE: From this point, fitting can be turned inward to a maximum of one additional turn for alignment purposes. If fitting tightens in nut before completing one and one-half turns or before fitting can be aligned, it is permissible for nut to turn with fitting for remainder of distance.

(7) With fitting held in properly aligned position, tighten jamnut to recommended torque and lockwire.

(8) Metal to metal contact between nut and mating part boss must be obtained without exceeding recommended torque values and no extrusion of preformed packing or backup ring is permitted. It is essential that proper values based on metal to metal contact mentioned above be observed when tightening jamnut. This will minimize possibility of fitting loosening and resultant thread wear.

B. Recommended torque limits and thread protrusion limits for various fittings are outlined in Figure 401 (Sheet 2). Measure thread protrusions as shown in Figure 401 (Sheet 3).

5. Assembly of Flexible Type Fittings

A. Flexible Fittings, Packing, and Retainer

See Figure 402.

(1) Moisten the seal and fitting threads with a light film of engine oil or PMC 9609 petrolatum.

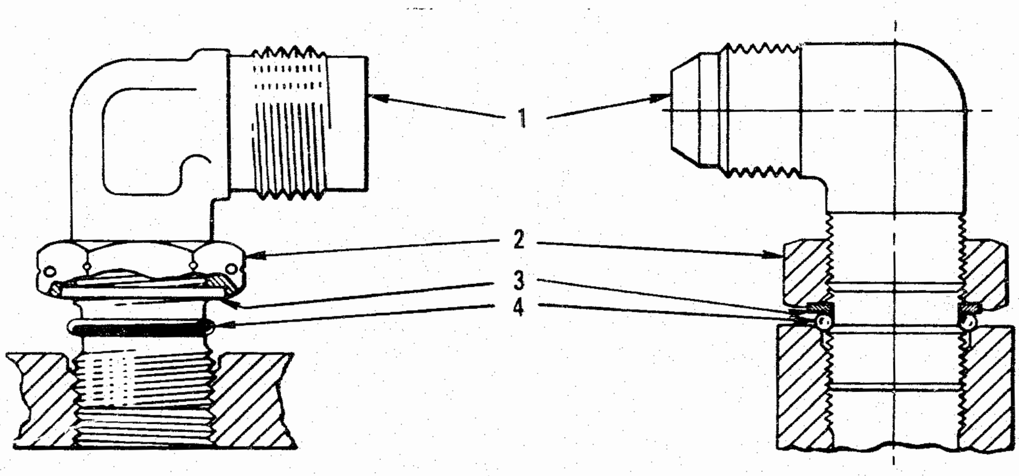
(2) Install seal on the tube end against the ferrule.

(3) Install the retainer on the tube positioning it against the packing or seal. Minimize stretching of the retainer to ensure a tight fit.

(4) Install tube to properly aligned connector and tighten nut to the recommended torque.

6. Installation of Elbow Type Fittings

CAUTION: BEFORE TIGHTENING TUBE COUPLING NUTS, BE SURE ELBOWS ARE PROPERLY ALIGNED. TUBE ENDS MUST BE CENTERED AT ELBOWS AND FREE TO MOVE. BINDING OF TUBE AND FITTING OR MISALIGNMENT MUST NOT BE PRESENT.



1. Connector Elbow
2. Jamnut
3. Packing
4. Seal

Preformed Packing and Type Connector
(Sheet 1 of 3)

Figure 401

THREAD PROTRUSION AND TORQUE LIMITS

THREAD SIZE	TORQUE LIMITS	FITTING PART NUMBERS	THREAD PROTRUSION LIMITS*
1.625-12	600-900	196826, 215812, 222090, 254498	1-2
		405623	0.900 to 1.000 inch from mating face of nut to mating face of coupling mount flange when nut is tight against adjacent part.
		332627, 462254	0.166" Max from undercut
		390998	0.476" Max from undercut
1.3125-12	500-700	183649, 198420, 214163, 253424	0-1
		226110, 227470, 323462	1/2 — 2-1/2
		183653	3-4
		170987 (with thread undercut)	1/2 — 1-1/2
		170987 (without thread undercut)	2-3
		417213	2-3
1.0625-12	300-500	235157, 307450, 314431, 317408	0-1
		226112	1-2
		418842	5-8
0.875-14	200-350	224913	2-3
		321677	1-2
0.750-16	150-250	223923, 278121	0.100" Max from undercut
		218217, 331583	0.234" Max from undercut
		232179, 443519	0-1
		341231	1/2 — 1-1/2
		155974, 321675	1-2
		150697, 227456, 361593	2-3
		355812	5-6
0.5625-18	75-125	229161	1-2
0.500-20	60-80	222172, 265050	1/2 — 1-1/2
		303035, 315335, 363010	1-2
		282715	2-1/2 — 3-1/2
		431952	0.105" Max from undercut
0.4375-20	40-65	190682	0.209" Max from undercut
		233548, 234097, 268652	0.080" Max from undercut
		240875, 360691	1/2 thread max
		168974, 170493, 183630, 237346	0-1
		243308, 252790, 331097, 433116, 454210	0-1
		164433, 224877, 249600, 252785	1/2 — 1-1/2
		260962, 266284, 307064, 361589, 388207	1/2 — 1-1/2
		210247, 228640, 276754	2-3
		348650, 381879	4-6
0.375-24	30-50	258086, 274359	1-3

*Limits shown are "Full Threads" exposed on the fitting, beyond the jamnut. A full thread is defined here as a thread crest with a complete root radius on each side of it.

High limit on thread protrusion is set to be sure that at least three full lower threads of fitting are engaged under all tolerance conditions. Thread protrusions below low limit indicate possible connection faults associated with fittings installed too deep (Seal or packing omission or extrusion, very loose nut, or inadequate seal annulus). If fitting is found to have too many threads exposed upon periodic service check, fitting must be removed and reinstalled. If there are still too many threads exposed, fitting must have extreme tolerances and if installation procedure was followed correctly, proper thread engagement may be assumed.

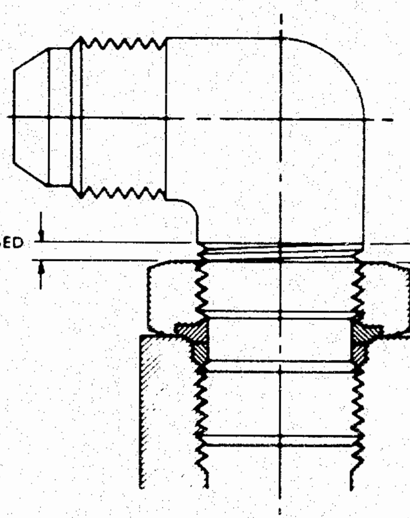
UNSATISFACTORY CONNECTION CONDITIONS AND METHODS OF PREVENTION

CONDITION	POSSIBLE RESULT	INSPECTION INDICATION
1. No Packing and/or seal	Leakage	Possibly beyond Thread Limits or Leakage Check
2. Inadequate Seal Groove - Fitting too deep	Leakage	Too few threads protruding or visible packing extrusion
3. Inadequate Seal Groove - Fitting too high	Leakage or See No. 4	Too many threads protruding
4. Insufficient lower thread engagement	Lower thread failure	Too many threads protruding
5. Loose Nut - Nut Undertorqued	Vibration failure of Lower threads	Test torque, or too few threads protruding or no metal to metal contact
6. Seal or Packing Extrusion	See No. 5 (Torque lost due to relaxation of pinched packing)	No metal to metal contact or visible extrusion
7. Re-use of seals, repositioning of fitting after tightening nut	Leakage	Leakage check

L-19071

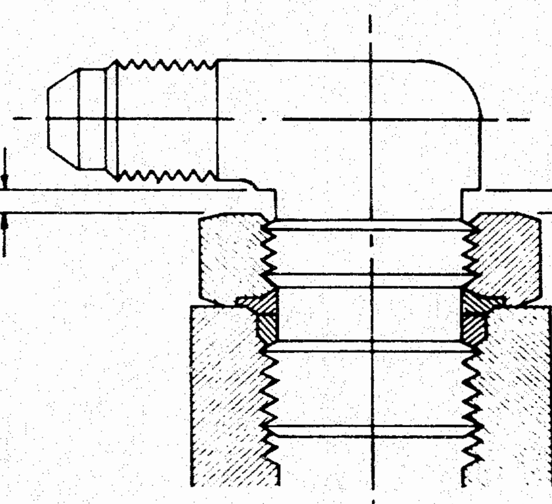
Preformed Packing and Jamnut
Type Connector (Sheet 2 of 3)

Figure 401



(b)
TYPICAL POSITION AFTER
INSTALLATION (STANDARD FITTING)

$$\left(\text{THREADS EXPOSED} = \tfrac{1}{2} \quad \frac{0+1}{2} = \tfrac{1}{2} \right)$$



(c)
TYPICAL POSITION AFTER
INSTALLATION (UNDERCUT FITTING)

To check thread protrusion, count *Whole Numbers* of full threads exposed at each end of a diameter and use the average of these two readings. For example, one-half thread means that one (or less than two) full thread is visible on one side and zero or less than one full thread is visible 180 degrees away, as shown in (b). For limits other than zero, a reading error of one-half thread is expected. When there is a thread undercut at the upper end of the fitting thread, in some cases even a zero thread high limit would not ensure sufficient engagement. For these cases, maximum dimensions have been given, from the rear face of the undercut to the nut, as shown in (c).

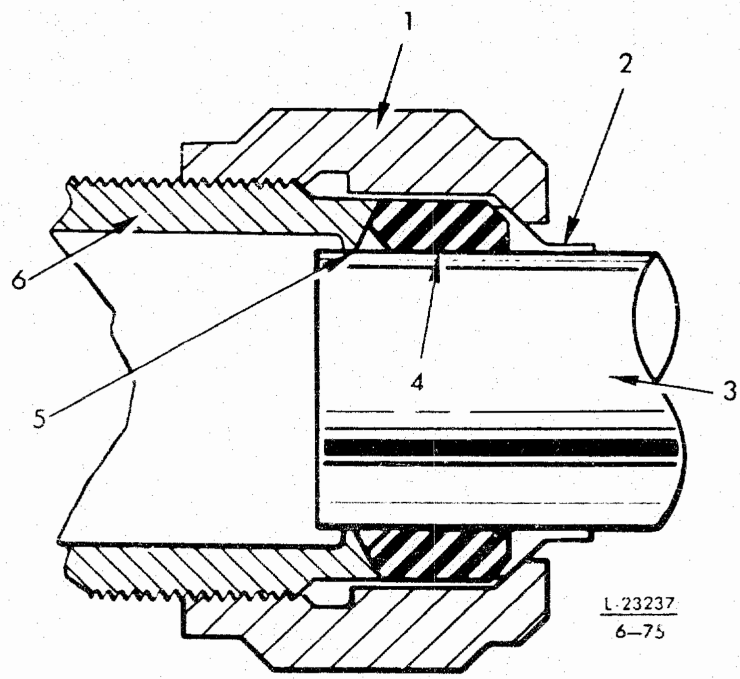
WARNING

L-7523

Failure to accomplish installation in accordance with these instructions may result in subsequent failure, fire, extensive damage and loss of life.

Preformed Packing Jamnut Type
Connector (Sheet 3 of 3)

Figure 401



1. Nut
2. Ferrule
3. Tube
4. Packing Or Seal
5. Retainer
6. Connector

Flexible Fittings
Figure 402

7. Antigalling and Antiseize Compounds

CAUTION: EXTREME CARE MUST BE EXERCISED TO ENSURE THAT ANTIGALLING AND ANTISEIZE COMPOUNDS ARE APPLIED IN A THIN EVEN COAT AND THAT ALL EXCESS MATERIAL IS COMPLETELY REMOVED SO AS TO AVOID ITS GETTING INTO OR ONTO PARTS, PASSAGES, OR SURFACES WHERE IT MAY CAUSE MALFUNCTIONS OR EVEN FAILURE OF ENGINE.

A. General

(1) Extreme pressure lubricants may be applied to certain areas such as spline drives, various case snaps, bearing journals, etc., at assembly to prevent galling of highly stressed surfaces.

(2) Antiseize compounds may be applied at assembly to facilitate disassembly of certain hot section and turbine treaded fittings.

(3) Penetrating oil may be used at disassembly to further facilitate disassembly of engines.

B. Materials

(1) Wet Fel-Pro C-200 or C-300 antigalling compounds are approved for threaded parts and mating faces of threaded and other parts in hot section and turbine areas. Optimum results are obtained with Fel-Pro C-200 baked on (SPOP 146), but use of wet Fel-Pro C-200 or C-300 brushed on without prior surface preparation or baking is permissible. In this latter use, less long term durability is obtained.

(2) Dgf-123 (PMC 9934) colloidal graphite dry film lubricant in a volitile carrier has been found satisfactory for use on ball sockets and in assembly of snugly fitting parts such as bearing races, spacers, and seals on hubs and shafts.

(3) All accessory splines which do not normally receive lubrication through engine system must be lubricated with Plastilube No. 3 compound.

CAUTION: SINCE MOLYBDENUM DISULFIDE IS NOT STABLE ABOVE 900°F (482°C) IT MUST NOT BE USED IN LOCATIONS WHERE OPERATING TEMPERATURES ARE IN EXCESS OF 900°F (482°C).

(4) Molybdenum disulfide, in either its powder form (PMC 9523) or suspended in some vehicle such as alcohol or engine oil, has been found satisfactory for use in assembling combustion chamber cases, turbine nozzle cases, exhaust cases, turbine shaft splines and threads.

(a) PWA 541 Antiseizing Compound Lubricant

1 Thoroughly mix molybdenum disulfide powder and grade 1010 oil in following proportions:

PMC 9523 powder	80 ± 3 percent by weight
PMC 9852 oil	20 ± 3 percent by weight

2 Continue mixing until lubricant is smooth and free from lumps, cakes, skins, and grit.

3 Store lubricant in closed contiainers to ensure freedom from undue contamination.

(5) Parker Thread Lube (PMC 9936) antigalling and antiseize compound is approved for spark igniter plug threads, studs, and steel threaded case assembly plugs.

(6) Marvel Mystery Oil (PMC 9534) gage lubricant is approved for use at engine teardown to facilitate disassembly of engines.

(7) Extreme pressure lubricant, lubriplate Mo. 130A or equivalent, has been found satisfactory for use on all tight press fit splines.

C. Restrictions

(1) Unless otherwise specified, antiseize or antigalling compounds must not be used at following locations.

(a) All face splines.

(b) All main rotor disk, hub, and spacer snaps.

(c) Conical seats.

(d) Fuel fittings.

8. Antiseize Compounds

A. In order to facilitate subsequent disassembly, apply Fel-Pro C200 antiseize compound to all threaded parts attached to hot section except silver plated threaded parts, fuel fittings, and locations where another compound is specified.

9. Gasket Lubricant (Gredag)

A. Where necessary, coat gasket surfaces with Gredag Lubricant to reduce possibility of gaskets adhering to surfaces of mating parts.

NOTE: Gasket lubricant is known as Gredag Lubricant No. 55 Graphited, and may be procured from Acheson Industries, Inc., Acheson Colloids Division, 1635 Washington Street, Port Huron, Michigan 48061.

ENGINE - DISMANTLING/ASSEMBLY

10. Keywashers

A. Definition and Purpose

(1) A keywasher is a washer-like locking device which uses keys (tabs) to lock parts together.

(2) These instructions concern single or multiple hole keywashers with two or three unbent keys (or tabs) per hole.

(3) An unbent key is one which is bent, or locked, following installation of the part, but which may be partially bent or preformed during manufacture.

B. Locking Procedure

(1) Once removed a new keywasher must be used at assembly. Use a keywasher only one time.

(2) All keys on the keywasher are to be bent as a safeguard against reuse.

(3) When locking a single hole keywasher bend one key full against a flat face on the nut or bolt head to be locked. Other keys may be bent in any convenient manner.

(4) When locking a multiple hole keywasher bend one key for each hole full against a flat face of the nut or bolt head being locked. Other keys may be bent in any convenient manner.

(5) When installing keywashers which have ID tabs which mate with a slotted shaft proceed as follows.

(a) Use fine crocus cloth, stone, or file to remove spalled or rough surface from face of nut. Remove sharp edges from inside tool slots and around outside diameter of nut face.

(b) Using a new washer, apply a one to one mixture of molybdenum disulphide, Molykote Type Z, powder and engine oil to face of washer which contacts nut. Remove excess lubricant.

(c) Install washer aligning ID tab with slot in shaft and retaining nut fingertight.

(d) Install an alignment mark across exposed area of washer and shaft or part which mates with washer ID tab.

(e) Tighten nut to recommended torque.

(f) Check alignment mark. Any misalignment indicates a sheared or weakened ID locking tab. Remove washer and repeat above procedure using a new washer, as necessary, to ensure proper locking of retaining nut.

(g) Bend external locking tabs of washer against nut. At least one tab shall be bent full against one flat of nut. Keywashers not having external tabs, crimp side into mating nut slot 180 degrees apart.

NOTE: If no special tool is provided for bending tabs use a brass drift.

C. Acceptable Standards

(1) Keywashers shall be considered properly locked when all keys for each hole have been bent against the nut or head to be locked.

(2) One of the keys must be full against a flat face of the nut or head with a gap which does not exceed 0.020 inch.

11. Identification of Hardware Material, Particularly Nuts and Bolts

A. A permanent type of material code designation has been adopted for use in these engines. Correct engine reassembly procedures require that particular attention be paid to the material requirements for nuts and bolts used in the hot section of the engine. In these areas, where parts must be of material which is resistant to high operating temperatures, special heat resistant alloys are employed. It is imperative that at reassembly of the engine or its components the properly coded part be reassembled in its original location, if serviceable.

B. The code system employs the use of a letter, "C", for corrosion resistant steel for normal application and "H" for heat resistant alloys in hot section application. The stamped or embossed letter will be followed by a number of one or more digits, such as C1, C8, H3, and H12. Bolt code identification will usually appear on the top of the head (see Figure 403) and nut identification on one side of the hex (see Figure 404). When the application is an AN or MS six digit part number, the code identification "C" or "H" will be preceded by the letter "E" as in EC3 or EH10.

NOTE: All AN and MS six digit part numbers, when manufactured of material in the common temperature range (such as cadmium plated, low alloy steel parts), are also coded "E" to indicate, in part, close material quality control.

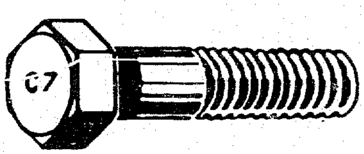
ENGINE - DISMANTLING/ASSEMBLY

C. Under step F is a complete list of specific material identification numbers. It is probable that new designations will be added from time to time. In the event that a material code number is preceded with the letter "P", it will be noted that this is a temporary PWA designation which will be used until such time as a "C" or "H" number is adopted.

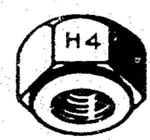
D. The adoption of this program will make it possible for service activities to avoid the assembly of parts, with similar physical appearance, in locations which require high heat resistant parts. In this regard, it is required, at time of disassembly, that all similarly coded parts be segregated so that two or more physically, similar parts with different code numbers will not be scrambled; and so that, at subsequent reassembly, the properly coded parts are replaced in their proper locations.

CAUTION: NEVER ASSEMBLE A MATERIAL CODED PART WITH A "C" IDENTIFICATION IN A LOCATION WHICH REQUIRES AN "H" CODED PART AND VICE-VERSA. NEVER USE CADMIUM PLATED NUTS, BOLTS, OR ANY OTHER CADMIUM PLATED PART IN THE HOT SECTION OF THE ENGINE. REFER TO THE LIMITS AND EXTERNAL PARTS CHARTS FOR CORRECT LOCATION OF CODED PARTS.

E. Parts from several engines should not be scrambled at disassembly and cleaning, because, at the time of engine manufacture, production requirements may necessitate one or more material substitutions in a block of engines. Subsequent engine reassembly, in the field, with indiscriminate scrambling of hardware, may result in unnecessary confusion in sorting these parts for proper reassembly.



Bolt Code Identification
Figure 403



Nut Code Identification
Figure 404

F. Corrosion, Heat Resistant and Special Material List

CORROSION RESISTANT MATERIALS

Material Specification	Code	Material Specification	Code
AMS 5640	C1	AMS 5624	C9
AMS 5628	C2	AMS 5639	C10
AMS 5515, 5516, 5517, AMS 5518, 5519, 5636 (Was C5), 5637, or 7472	C3	AMS 5738	C12
		AMS 5630	C13
AMS 7228	C4	AMS 5643	C14
AMS 5354, 5508, 5616, or AMS 7470	C6	AMS 5625	C15 (Was P10)
		AMS 5506, 5620, or 5621	C16
AMS 5610	C7	AMS 5644	C17
AMS 5504 (Was C11), AMS 5612, or 5613	C8	AMS 5743	C18

HEAT RESISTANT MATERIALS

Material Specification	Code	Material Specification	Code
AMS 7229	H1	AMS 5524 or 5648	H8
AMS 7232	H2	AMS 5540, 5580 or 5665	H9
AMS 5526, 5527, 5720 (Was H13), 5721, 5722, or AMS 7476	H3	AMS 5521, 5572, or 5651	H11
		AMS 5522 or 5652	H12
AMS 5642	H4	AMS 5720	H13
AMS 5512, 5571, or 5646	H5	AMS 5542, 5667 (Was H10), or 5668	H14
AMS 5733 (PWA 746)	H6	Chromel	H15
AMS 5510, 5557, 5559, AMS 5570, 5576, or 5645	H7	Alumel	H16

ENGINE - DISMANTLING/ASSEMBLY

HEAT RESISTANT MATERIALS (continued)

Material Specification	Code	Material Specification	Code
AMS 5649	H17	AMS 5551, 5756, or 5757	H24
AMS 5532 or 5768	H18	AMS 5660, PWA 1003 (Was PWA 1002)	H25 (Was P11)
AMS 5525, 5731, 5732, AMS 5734, 5735 (Was PWA 747, P4), 5736, 5737, or AMS 7481	H19 or Knurl*	AMS 5706, 5708 (Was PWA 90), 5709, 7471, PWA 686, PWA 687 (Was CF236, P18), or PWA 1004	H26 (Was P15)
AMS 5514 or 5647	H20	AMS 5759	H27
AMS 5754	H21 (Was P19)	AMS 5662 or PWA 1009	H28
AMS 5530 or 5750			
AMS 5545, 5712, 5713, or AMS 7469	H23		

*NOTE: Knurl on washer face diameter is sometimes used on double-hex castellated nuts for material identification instead of code.

TITANIUM OR TITANIUM ALLOY

Material Specification	Code	Material Specification	Code
AMS 4921	T1 (Was P8)	AMS 4927	T4
AMS 4923	T2	AMS 4928 (Was PWA 682, P12), 4967, or 7461	T5
AMS 4925	T3	AMS 4929	T6

SPECIAL MATERIAL

Material Specification	Code	Material Specification	Code
AMS 6304 (Was PWA 722, P5) 7454, 7455, or 7458	S37 or E37	PWA 91	P25
		PWA 1006, 1008, or 1013	P26
AMS 5620	P3	AMS 7236	P27
AMS 6302 (Was P9)	Inactive	AMS 5666	P28
PWA 1202	P20	ASTM A 453 Grade 660	660
PWA 1010	P21	ASTM A 193 B7	B7
AMS 7477	P23	ASTM A 193 B16	B16
AMS 7461	P24		

G. Stainless Steel Bolts with Reduced Pitch Diameters

(1) At engine manufacture, it is the practice to provide bolts with reduced pitch diameter for use in hot sections of engines. This will minimize possibility of bolt and nut seizure. This is standard practice for locations where parts are subjected to temperatures in excess of 500°F (260°C).

12. Standard Torques

A. General

(1) Use standard torque values in locations where no specific torque is given in text or clearance charts (Fits and Clearances Sections).

(2) Torque values for J threads are identical to torques applied to standard threads.

(3) The torque limits listed in this section shall be interpreted as follows:

(a) Torque values in pound-inches.

(b) Angles of turn in degrees.

(c) Stretch values in inches.

(4) Unless otherwise specified, thread lubricants shall be applies to parts which are to be torqued. Thread lubricant shall be engine oil or equivalent, or specific antiseize compounds.

(5) If part to be tightened is hot, allow sufficient time to elapse to allow temperature of part to reach a temperature equilibrium with surrounding area before final torquing.

(6) Extreme care should be exercised in joining of flanges or mating sections during assembly. When joining snap fits, it is essential that mating parts be properly seated prior to application of final torque. Unless specific procedures are provided in assembly instructions, parts should be seated by installing several bolts at regular intervals then applying uniform torque where required to seat mating surfaces. Once seating is assured, all bolts should be torqued to approximately 75 percent of final torque in a uniform stagger (180°, 90°, and 45° intervals, etc.) to preclude local overstressing of bolts or flange. Final torque should be applied in same sequence.

(7) Torque applications should be done slowly and evenly for consistency and best possible accuracy. There may be instances, other than specific torque limits, where it is obvious that standard torque required should not be used due to kind of material or design of engine part involved. Common sense and good judgment should of course be exercised in such cases.

13. Torque Indicating Devices

A. Check torque indicating devices by schedule below and calibrate by means of weights and a measured lever arm to make sure that there are no inaccuracies. Checking one torque wrench against another is not sufficient. Some wrenches are quite sensitive to way they are supported during a tightening operation, and every effort must be made to adhere to instructions furnished by respective manufacturers.

(1) Set-type torque wrenches: Check once a week.

(2) Non-set-type torque wrenches: Check every four weeks.

B. Torque Wrench and Extensions

(1) Occasionally, it is necessary to use a special extension, or adapter wrench together with a standard torque wrench. See Figure 405.

Example: A torque of 1440 pound-inches is desired on a part, using special extension having a length of three inches from center to center of its holes, and a torque wrench, measuring 15 inches from center of handle or handle swivel pin to center of its square adapter.

$$\text{Then: } R = \frac{LT}{L+E} = \frac{15x1440}{15+3} = 1200$$

(2) With axis of extension or adapter and torque wrench in a straight line, tightening to a wrench reading of 1200 pound-inches will provide desired torque of 1440 pound-inches on part.

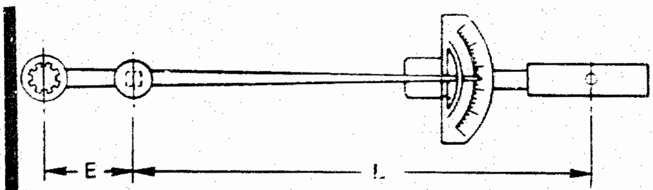
NOTE: The effective length of P&WA special extensions, adapters, and wrenches is stamped on tool

14. General Torque Recommendations

A. Lubricants and Lubrication

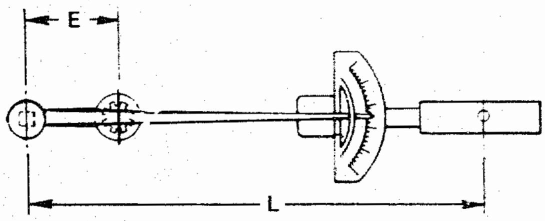
(1) Oil Lubricated Parts

(a) Torque limits given in this section for oil lubricated parts apply specifically to use of engine oil, or equivalent, on parts.



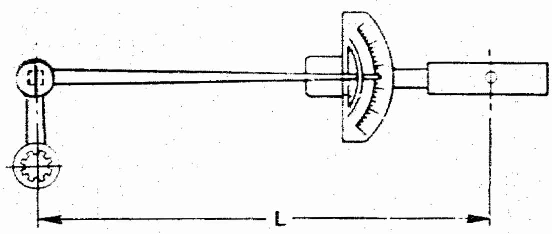
A CORRECTION OF THE INDICATED TORQUE READING IS REQUIRED WHEN AN ADAPTER IS USED, WHICH CHANGES THE EFFECTIVE LENGTH OF A TORQUE WRENCH. APPLY FOLLOWING FORMULA TO OBTAIN THE CORRECTED TORQUE READING.

$$R = \frac{L \times T}{L + E}$$



A CORRECTION OF THE INDICATED TORQUE READING IS REQUIRED WHEN AN ADAPTER IS USED, WHICH CHANGES THE EFFECTIVE LENGTH OF A TORQUE WRENCH. APPLY FOLLOWING FORMULA TO OBTAIN THE CORRECTED TORQUE READING.

$$R = \frac{L \times T}{L - E}$$



A CORRECTED TORQUE READING IS NOT REQUIRED WHEN AN ADAPTER IS USED WHICH DOES NOT CHANGE THE EFFECTIVE LENGTH OF THE TORQUE WRENCH

LEGEND

T = DESIRED TORQUE
E = EFFECTIVE LENGTH OF EXTENSION OR ADAPTER
L = EFFECTIVE LENGTH OF TORQUE WRENCH
R = CORRECTED TORQUE READING

NOTES

(1) DO NOT USE A HANDLE EXTENSION ON ANY TORQUE WRENCH.
(2) EFFECTIVE LENGTH OF PWA SPECIAL EXTENSIONS, ADAPTERS, AND WRENCHES IS STAMPED ON TOOL.

Computing Effect of Torque Wrench Extensions

Figure 405

(2) Antiseize Lubricated Parts

(a) Torque limits given in this section for antiseize coated parts apply specifically to the use of antiseize compounds applied in accordance with SPOP 145, 146, 156, 160, or 161, or to wet applications of Fel-Pro C-200 and C-300, and Ease-Off 990, or to Kaylube 3.

B. Nuts, Bolts, and Screws.

(1) General

(a) Torque values listed in Table I for nuts, bolts, and screws have been established to provide sufficient pre-load without overstressing the parts and are based on materials having minimum ultimate tensile strengths of 125,000 pounds per square inch, equivalent to Rockwell C26 hardness for steel parts.

NOTE: The torque values specified in Table I apply to bolts in standard helical coil inserts as long as full thread engagement of insert is accomplished.

(2) Thin Nuts, Slotted Nuts

(a) The torque values in Table I shall appply to nuts where height of the nuts is greater than 75 percent of the major diameter of the thread. For thin nuts, where the height of the nuts is 40 to 75 percent of the size of the major diameter, reduce the torque values 50 percent. Slots in slotted nuts should be disregarded in figuring height of nut. Values do not apply to hollow bolts and screws.

(3) Safety Wire and Cotterpin Requirements

(a) After a castle nut, screw or bolt has been tightened to the proper torque, it should not be loosened to permit the insertion of safety wire or a cotterpin. If the slot in the nut or the safety wire hole in the bolt or screw is not properly aligned at the minimum torque limit, the nut, screw or bolt should be further tightened to the next aligning position, but the maximum torque limit must not be exceeded. If alignment cannot be accomplished without exceeding the maximum limit, back off the nut, screw or bolt half a turn, then retighten. It may be necessary to select a new part.

C. Self-Locking Nuts

(1) Free Spinning Locknuts.

(a) Free spinning locknuts are nuts that spin freely on the bolt or stud until it contacts the mating surface with activation of the locking feature produced with additional torque. Use the torque values listed in Table I.

ENGINE - DISMANTLING/ASSEMBLY

Thread Size**	Torque (lb.—in.)					
	Oil Lubricated			Antiseize Coated		
	Max.	Min.*		Max.	Min.*	
		Type I	Type II		Type I	Type II
.112—40	6	4.5	5	4.5	3.5	4
.138—32	11.5	8.5	10	8.5	6.5	7.5
.164—32	22	16	20	16.5	12.5	15
.164—36	24	18	22	18	13.5	16
.190—24	30	23	27	21.5	16	19.5
.190—32	36	24	32	26	19.5	23
.216—24	48	35	43	35	26	31
.216—28	50	35	45	38	28	34
.250—20	70	50	65	50	37	45
.250—28	85	65	75	60	45	54
.3125—18	150	110	135	105	80	95
.3125—24	170	125	150	120	90	110
.375—16	270	200	250	185	140	170
.375—24	300	225	275	215	160	190
.4375—14	425	325	375	300	225	270
.4375—20	475	350	425	340	255	310
.500—13	650	500	600	450	340	400
.500—20	750	550	675	515	390	460
.5625—12	950	700	850	675	500	600
.5625—18	1050	800	950	750	550	675
.625—11	1300	1000	1200	900	675	800
.625—18	1500	1150	1350	1025	775	925
.750—10	2300	1700	2100	1600	1200	1450
.750—16	2600	2000	2400	1800	1350	1600
.875—9	3700	2800	3400	2600	1950	2350
.875—14	4200	3200	3800	2900	2200	2600
1.000—8	5600	4200	5100	3900	2900	3500
1.000—12	6400	4800	5800	4300	3200	3850
1.125—7	7900	5900	7200	5400	4100	4900
1.125—8	8400	6300	7600	5700	4300	5100
1.250—7	11200	8400	10100	7700	5800	6900
1.250—8	11700	8800	10600	7900	5900	7100
1.375—6	14700	11000	13300	10100	7600	9100
1.375—8	15900	11900	14400	10600	8000	9500
1.500—6	19600	14700	17700	13300	10000	12000
1.500—8	21100	15800	19000	14000	10500	12600
1.750—5	30900	23200	27900	21100	15800	19000
1.750—8	34500	25900	31100	22700	17000	20400
2.000—4.5	46600	35000	42000	31700	23800	28500
2.000—8	52600	39500	47400	34400	25800	31000

*Use Type I minimum torque values where alignment of locking holes (for cotterpins, lockwire, etc.) is required at assembly. Use Type II minimum values where locking hole alignment is not required at assembly.

**For screws larger than 0.164 thread size having screwdriver slots only (no external wrenching provision):

1. For non-self-locking applications, 22 lb.—in. minimum is permissible.
2. For self-locking applications, permissible minimum torque is 22 lb.—in. plus torque required to turn screw through nut.

L—41653
7—75

(2) Prevailing Torque Type Locknut.

(a) Prevailing torque type locknuts are nuts that spin freely on bolt or stud until threads enter locking portion of nut. At this point bolt interferes with deformed section of nut causing tight frictional hold on bolt thread flanks. Use torque values listed in Table II except when nut is on stud, then use Table I.

NOTE: Helical coil self-locking inserts are categorized as prevailing torque type locknuts. The torques for bolts used in such inserts are listed in Table II.

(b) Effective locking of slotted steel locknuts on bolts or studs requires full engagement of all locknut threads. It is not necessary for bolt or stud to protrude beyond outer end of locknuts because chamfered part of locknut ID does not exert locking force on bolt or stud.

D. Steel Pipe Plugs in Aluminum and Magnesium Cases

(1) The torque values for steel pipe plugs in aluminum and magnesium cases listed in Table III have been established to provide for tightening plugs sufficiently to prevent leakage without overstressing cases. If pipe plug is found to leak after it has been tightened to these limits and sealing compound has been applied to threads, it should not be tightened further, but should be removed and more sealing compound should be applied to threads; plug should then be reinstalled and retightened to indicated limits.

(2) When plugs are tightened in hot engine, torques should be reduced about 20 percent to allow for difference in expansion between steel plugs and aluminum or magnesium cases.

E. Hex-Head, Straight-Threaded Fittings and Plugs (MS9015, MS9193 or Similar)

CAUTION: EXCESSIVE TIGHTENING WILL RESULT IN DAMAGE TO THREADS OF MATING PARTS.

(1) The torques listed in Table IV are based on strength of thread in cast aluminum or magnesium; they may be used in stronger materials.

F. Flexible Tube Connections (such as Sealastic Type Fittings)

See Figure 405A.

(1) When assembling flexible tube connections, seal and fitting threads must be lubricated with light film of engine oil or petrolatum. Seal must be bottomed and tube aligned before applying torque listed in Table IV.

Thread Size	Torque (lb.—in.)	
	Oil Lubricated	Antiseize Coated
.112–40	6–7	5–6
.138–32	12–14	9–11
.164–32	23–26	18–20
.164–36	25–28	20–22
.190–24	32–35	24–27
.190–32	36–40	27–30
.216–24	48–54	36–40
.216–28	50–56	40–44
.250–20	74–82	55–62
.250–28	85–95	62–72
.3125–18	160–175	115–130
.3125–24	180–200	125–140
.375–16	270–300	200–220
.375–24	290–325	225–250
.4375–14	420–465	315–350
.4375–20	450–500	340–380
.500–13	630–700	450–500
.500–20	720–800	515–575
.5625–12	950–1050	675–750
.5625–18	1050–1150	750–825
.625–11	1250–1400	900–1000
.625–18	1450–1600	1030–1150
.750–10	2200–2450	1600–1750
.750–16	2500–2750	1750–1950
.875–9	3600–4000	2500–2850
.875–14	4000–4450	2800–3100
1.000–8	5400–6000	3800–4200
1.000–12	6000–6700	4000–4500
1.125–7	7600–8200	5300–5700
1.125–8	8000–8700	5500–6000
1.250–7	10500–11600	7300–8100
1.250–8	11000–12100	7500–8300
1.375–6	13800–15100	9600–10500
1.375–8	14900–16300	10000–11000
1.500–6	18200–20100	12500–13800
1.500–8	19500–21600	13100–14500
1.750–5	28500–31500	19600–21700
1.750–8	31700–35100	21000–23300
2.000–4.5	42800–47400	31800–32500
2.000–8	48200–53400	29300–35200

L–41645
7–75

Torques for Self-Locking Nuts and Bolts, and
for Bolts Used in Helical Coil Self-Locking Inserts

Table II

ENGINE - DISMANTLING/ASSEMBLY

Thread size (ANPT or NPT)	Torque (lb-in.)	Thread size (ANPT or NPT)	Torque (lb-in.)
.062	30- 40	.500	140-160
.125	30- 40	.750	210-230
.250	70- 85	1.000	285-315
.375	95-110	1.250	355-385

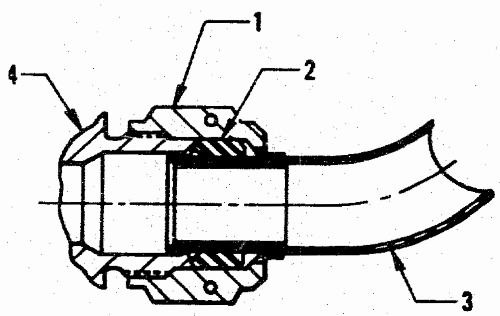
L-41637

Table III - Steel Pipe Plugs in Aluminum or Magnesium Cases

Thread size	Torque, lb-in.	Thread size	Torque, lb-in.
.250 -28	15- 20	1.0625-12	375-425
.3125-24	35- 40	1.1875-12	450-550
.375 -24	40- 50	1.250 -12	500-600
.4375-20	65- 75	1.3125-12	525-625
.500 -20	90-100	1.500 -12	600-700
.5625-18	110-120	1.625 -12	650-750
.625 -18	150-170	1.750 -12	650-750
.750 -16	200-225	1.875 -12	650-750
.8125-16	225-250	2.250 -12	650-750
.875 -14	250-275	2.500 -12	650-750
1.000 -12, -14	275-300		

L-41629
7-75

Table IV - Hex-Head, Straight-Threaded Fittings and Plugs



L-29739

3-72

1. Nut; See Table V
2. Packing
3. Tube
4. Fitting

PWA Flexible Fitting

Figure 405A

Tube Dia.	Thread Size	Part Number for 75 Durometer A Packings: AMS 7260, 7267, or 7273	Torque lb-in	Part Number for 77 Durometer C (100 Durometer A) Packings: PWA 401	Torque lb-in.
0.250	0.625-18	227407	25 - 30	399615	55 - 60
0.3125	0.6875-16	227413	30 - 35	451083	65 - 70
0.375	0.750-16	226366, 626155	30 - 35	410629	65 - 70
0.4375	0.8125-16	227419	45 - 50		
0.500	0.875-14	227401, 598643 669480	55 - 60	391009	100 - 120
0.5625	1.000-12	227425	60 - 65		
0.625	1.0625-12	226195	65 - 70	443330	130 - 140
0.750	1.1875-12	227427	70 - 80	389114	140 - 160
0.875	1.375-12	227431	75 - 85	452427	150 - 170
1.000	1.500-12	227433	100 - 110	389847	200 - 220
1.125	1.625-12	227451	100 - 110	409309	200 - 220
1.250	1.750-12	227439, 598678	100 - 110	414121	200 - 220
1.500	2.125-12	227445	100 - 110	409179	200 - 220

Table V - PWA Flexible Fittings

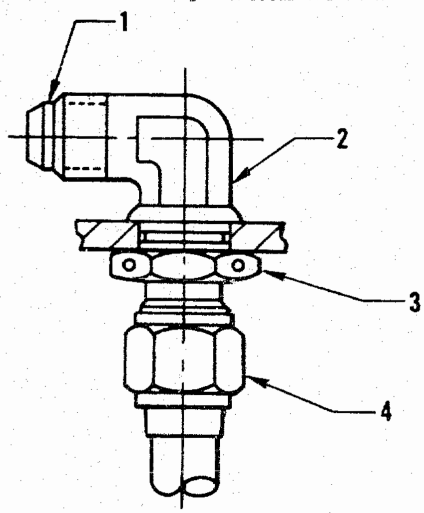
(2) It is expected that these flexible tube connections will experience slight loss of torque over a period of time due to seating of rubber in mating parts. To minimize this condition, parts should be torqued to listed value, then loosened, and torqued again to listed value.

G. Cone Seat Connectors

See Figure 405B.

(1) For 37° cone seat connectors without gaskets, use torque values listed in Table VI.

(2) For 37° cone seat connectors with nickel gaskets, use torque values listed in Table VII.



1. Cone Seat Connector, Before Assembling Mating Parts; See Table VI or VII.
2. Bulkhead Fitting
3. Jamnut; See Table VIII.
4. Cone Seat Connector Nut; See Table VI or VII.

L-29740

Cone Seat Connector, and Bulkhead Fitting Jamnut
Figure 405B

Hose size	Tubing OD	Thread size	Torque, lb-in. Aluminum fittings** All lubricants	Torque, lb-in. Steel and titanium fittings* Oil lubricated	Torque, lb-in. Steel and titanium fittings* Anti-seize coated
-3	.1875	.375 -24	30- 50	70- 80	50- 60
-4	.250	.4375-20	40- 65	90- 100	65- 75
-5	.3125	.500 -20	60- 80	135- 150	100- 110
-6	.375	.5625-18	75-125	270- 300	200- 225
--	.4375	.625 -18	100-175	320- 350	225- 250
--	--	.6875-24	--	320- 350	225- 250
-8	.500	.750 -16	150-250	450- 500	340- 375
--	.5625	.8125-16	175-300	550- 600	400- 450
-10	.625	.875 -14	200-350	650- 700	475- 525
--	--	.875 -16	200-350	650- 700	475- 525
--	.6875	1.000 -12	275-450	800- 900	600- 675
--	--	1.000 -14	275-450	800- 900	600- 675
-12	.750	1.0625-12	300-500	900-1000	675- 750
--	.875	1.1875-12	400-600	1100-1200	825- 900
--	--	1.250 -12	400-650	1150-1300	900-1000
-16	1.000	1.3125-12	500-700	1300-1400	950-1050
--	1.125	1.500 -12	600-900	1500-1600	1050-1200
-20	1.250	1.625 -12	600-900	1700-1800	1150-1300
-24	1.500	1.875 -12	600-900	2100-2200	1500-1600

* If the nut or either of the mating sealing surfaces is aluminum, the required torque limits for aluminum fittings apply.

** For thrust reverser air line fittings, use torques for aluminum fittings, regardless of material, unless otherwise specified.

L-41613
7-75

37 Degree Cone Seat Connectors
Without Gaskets

Table VI

ENGINE - DISMANTLING/ASSEMBLY

(3) Do not attempt to correct any leakage of joint by overtorquing. Disassemble fitting and check for nicks, burrs, dirt, etc. If necessary, use new parts.

H. Jamnuts

See Figures 405B and 405C.

(1) The torques listed in Table VIII are to be used for all steel and aluminum jamnuts (locknuts) of type used on fittings for tube and hose connections.

Hose size	Tubing OD	Thread size	Torque, lb-in.		
			Steel fittings		Titanium fittings
			Oil lubricated	Anti-seize coated	Anti-seize coated*
-3	.1875	.375 -24	50- 60	40- 45	50- 60
-4	.250	.4375-20	90- 100	65- 75	90- 100
-5	.3125	.500 -20	135- 150	100- 110	135- 150
-6	.375	.5625-18	200- 220	150- 165	200- 220
--	.4375	.625 -18	250- 270	185- 200	250- 270
-8	.500	.750 -16	350- 400	270- 300	350- 400
--	.5625	.8125-16	400- 450	300- 350	400- 450
-10	.625	.875 -14	500- 550	360- 400	500- 550
--	.6875	1.000 -12	600- 700	480- 530	600- 700
-12	.750	1.0625-12	700- 800	540- 600	700- 800
--	.875	1.1875-12	800- 900	600- 675	800- 900
-16	1.000	1.3125-12	1000-1100	750- 825	1000-1100
--	1.125	1.500 -12	1300-1400	900-1000	1300-1400
-20	1.250	1.625 -12	1400-1500	1000-1100	1400-1500
-24	1.500	1.875 -12	1600-1700	1200-1300	1600-1700

* Spec PWA 550 and Spec PWA 586

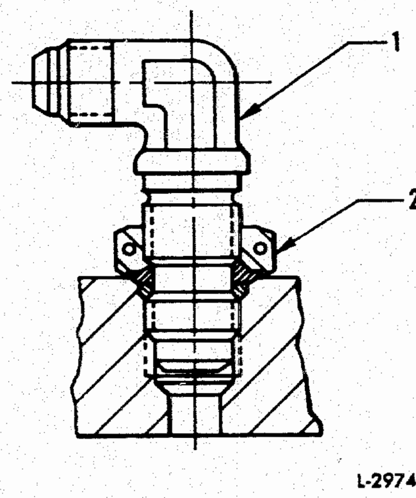
L-41605
7-75

Table VII - 37 Degree Cone Seat Steel Connectors With Nickel Gaskets

Thread size	Torque, lb-in.	Thread size	Torque, lb-in.
.250 -28	14- 16	1.1875-12	350-390
.3125-24	22- 24	1.250 -12	380-420
.375 -24	28- 32	1.3125-12	475-525
.4375-20	38- 42	1.500 -12	570-630
.500 -20	58- 62	1.625 -12	570-630
.5625-18	70- 80	1.875 -12	570-630
.625 -18	95-105	2.250 -12	570-630
.750 -16	145-155	2.500 -12	570-630
.8125-16	165-185		
.875 -14	190-210		
1.000 -12	260-290		
1.0625-12	285-315		

L-41597

Jamnuts
Table VIII



1. Boss Fitting; See Text
2. Jamnut: See Table VIII

Preformed Packing and Jamnut Type Connector
Figure 405C

(2) On elbow fittings, jamnut shall be torqued after connecting tube or hose has been installed and properly aligned.

I. Installation of Crush Type, Asbestos Filled Gaskets

(1) Install all crush type gaskets, except self-centering type, with unbroken surface against flange of plug or part being tightened against seal. Turn mating part until sealing surfaces are in contact and tighten to angle of turn shown in Table IX for appropriate thread pitch.

J. Installing and/or Attaching Various Components of Ignition and Thermocouple Systems.

See Figure 405D.

(1) Torque all plug-in type threaded connections fingertight plus a 45° maximum turn. See Figure 405D.

(2) Igniter Plugs

(a) All igniter plugs except "slim line" igniter plugs should be installed in engines with a torque of 300 to 360 pound-inches.

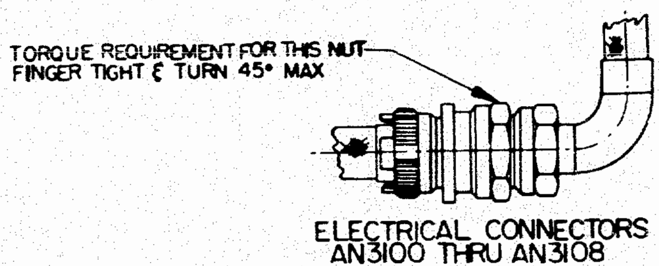
(b) "Slim-line" igniter plugs are considered special. Specific installation instructions will be given in publications directing their use.

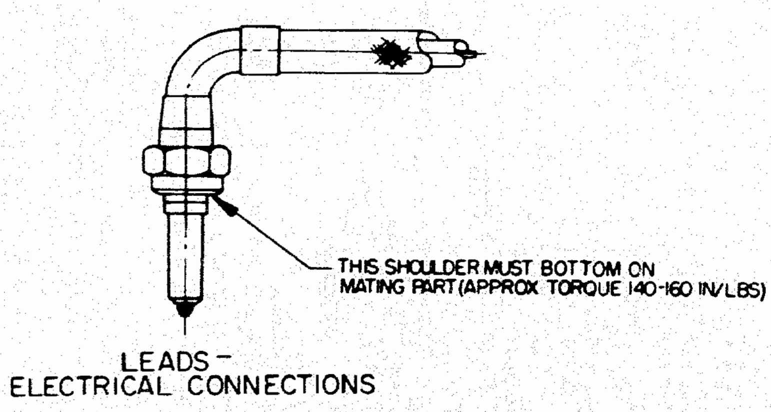
Thread Pitch on Part to be Tightened (Threads per Inch)	Angle of Turn (Degrees, ± 5 Degrees)*	
	Aluminum/Asbestos	Copper/Asbestos Nickel/Asbestos Steel/Asbestos
8	135	67
9	135	67
10	135	67
11	180	90
12	180	90
13	180	90
14	180	90
16	270	135
18	270	135
20	270	135
24	360	180
28	360	180

*These values provide for compression of approximately 40 percent for aluminum/asbestos and 20 percent for copper/asbestos, nickel/asbestos, and steel/asbestos gaskets.

L-41589
7-75

Table IX - Metal-Asbestos Gaskets





Installation of Plug-In and "Cigarette"
Type Electrical Connections

Figure 405D

(3) All "cigarette" type electrical connections (intermediate voltage leads and high tension leads) shall be torqued until the connection is bottomed on its shoulder. This normally takes approximately 140 - 160 pound-inches of torque. See Figure 405D.

(4) All exhaust temperature probe terminal attaching nuts and thermocouple harness-to-lead attaching screws shall be torqued as shown in Table X unless otherwise specified.

(5) In exhaust gas temperature junction box, all harness terminal and bus bar attaching nuts should be torqued as shown in Table XI.

K. Torque Check for Reuse of Self-Locking Nuts.

(1) Check self-locking nuts for adequate torque before reuse. Discard nut if locking capability is impaired. Do not attempt repair.

(2) Torque limits.

(a) Self-locking nuts shall be capable of meeting torque requirements in Table XIA when lubricated with engine oil, and at room temperature.

(b) For torque testing stainless steel, corrosion and heat resistant steel, nickel alloy steel, and AMS 6304 nuts, major, minor, and pitch diameters of bolts should be reduced 0.003 inch below dimensions specified for listed 0.190-32 UNF-3A, 0.190-24 UNC-3A and larger bolt sizes. See Table XIA.

(3) Unplated Nuts.

(a) Unplated stainless steel, corrosion resistant steel, nickel alloy steel, and AMS 6304 steel nuts that have threads undercut for plating at assembly, shall be silver plated 0.0003 = 0.0006 inch thick for test purposes, and checked for requirements of Table XIA on unplated bolts threaded per Table XIA.

Thread size	Torque, lb-in.
.138-32	8-10
.164-32	8-12
.190-32	10-15
.216-32	30-35
.250-32	35-40

L-41581

Table X - Temperature Probe Nuts and Screws

Thread size	Torque, lb-in.
.190-32	25-30
.164-32	20-25

L-41573

Table XI - Harness Terminal And Bus Bar Nuts

(b) Unplated stainless steel, corrosion resistant steel, nickel alloy steel, and AMS 6304 steel nuts that are permanently attached to brackets as other similar parts, and that are not subsequently plated at assembly, shall be checked for requirements of Table XIA with bolts that are plated 0.0003 - 0.0006 inch thick. Plated bolts 0.190 inch in diameter and larger shall have threads reduced 0.0003 from class 3A limits on major, minor, and pitch diameters. Bolts smaller than 0.190 inch in diameter shall have class 2A tolerances. See Table XIA.

(c) Unplated carbon or alloy steel nuts shall be cadmium plated 0.0002 - 0.0005 inch thick and checked with cadmium plated bolts threaded per Table XIA.

Fine Thread Series			*Coarse Thread Series*		
Mating Bolt Thread Size**	***Max Locking Torque****	***Min Break-away Torque***	***Mating Bolt Thread Size*****	***Max Locking Torque****	***Min Break-away Torque***
.112 -48 NF-2A	3	0.5	.112 -40 NC-2A	3	0.5
.138 -40 NF-2A	6	1.0	.125 -40 NC-2A	4	1.0
.164 -36 NF-2A	9	1.5	.138 -32 NC-2A	6	1.0
.190 -32 UNF-3A	13	2.0	.164 -32 NC-2A	9	1.5
.250 -28 UNF-3A	30	3.5	.190 -24 UNC-3A	13	2.0
.3125-24 UNF-3A	60	6.5	.250 -20 UNC-3A	30	4.5
.375 -24 UNF-3A	80	9.5	.3125-18 UNC-3A	60	7.5
.4375-20 UNF-3A	100	14.0	.375 -16 UNC-3A	80	12.0
.500 -20 UNF-3A	150	18.0	.4375-14 UNC-3A	100	16.5
.5625-18 UNF-3A	200	24.0	.500 -14 UNC-3A	150	24.0
.625 -18 UNF-3A	300	32.0	.5625-12 UNC-3A	200	30.0
.750 -16 UNF-3A	400	50.0	.625 -11 UNC-3A	300	40.0
.875 -14 UNF-3A	600	70.0	.750 -10 UNC-3A	400	60.0
1.000 -14 NF-3A	800	92.0	.875 -9 UNC-3A	600	82.0
1.125 -12 UNF-3A	900	117.0	1.000 -8 UNC-3A	800	110.0
1.250 -12 UNF-3A	1000	143.0	1.125 -8 UNC-3A	900	137.0

*Installation or removal.
**Use the listed bolt sizes for torque testing cadmium plated nuts, carbon steel nuts, alloy steel nuts, and aluminum nuts.

L-18667

Torque Limits For Reuse of Self-Locking Nuts (Pound-Inches)

Table XIA

(d) Unplated aluminum nuts shall be checked with cadmium plated bolts threaded per Table XIA.

14A. Specific Fits and Clearances And Torque Recommendations

A. General

(1) Reference numbers on figure indicate location of fits, clearances, and parts for which torques are specified. A description of, and limits for, these fits, clearances, and torques are located in tables by corresponding reference numbers.

(2) In locations where no specific torque limit is given in clearance index charts, general torque recommendations given in this section apply.

B. Dimensions for Reference

(1) The Minimum and Maximum columns contain minimum and maximum blueprint dimensions for two mating parts. This information is furnished for reference only.

C. Limits

(1) The Minimum and Maximum columns contain desired fits and clearances between new parts. The figures in Replace column indicate allowable limit to which parts may wear before replacement is necessary at overhaul.

D. Terms and Symbols

(1) The symbol T in Minimum and Maximum column indicates tight fit. An asterisk (*) in Replace column indicates that parts should be replaced if any looseness if found. The term Fit To means that grinding, filing, or other fitting operation may be necessary to obtain desired fit at assembly. The symbol (#) means that gears shall be replaced when service use may have produced scuffing, pitting, galling, or excessive wear of any of parts. Unless otherwise specified, all fits are diametrical except spline fits which are calculated from chordal dimensions.

(2) Letter number codes on clearance charts enclosed with circle, such as A12 are of contractor significance only and shall be ignored. Letter-number codes with parentheses, such as (C-8) related to coordinates on outer margins of each clearance chart to facilitate location.

E. Units

(1) The figures in Minimum, Maximum, and Replace columns shall be interpreted as follows: torque in pound-inches and all other limits in inches.

ENGINE - DISMANTLING/ASSEMBLY

F. General Torque Recommendations

(1) Torque Application

(a) Unless otherwise specified, thread lubricants shall be applied to parts which are to be torqued. Thread lubricant shall be engine oil or equivalent, or specific antiseize compounds.

(b) Where torque figures for castle nuts are provided in Minimum column only, these nuts shall be tightened to designated torque and then further tightened, if necessary, to properly align locking slot.

(c) Where torque figures for castle nuts are provided in Minimum and Maximum columns, alignment of locking slot must be obtained without exceeding maximum torque. If this is not possible, another nut shall be used.

(d) Nuts tightened to recommended torque shall not be loosened to permit insertion of lockwire or cotterpins.

(e) When retaining nuts securing heated parts must be torqued, allow parts to reach temperature equilibrium before final tightening to recommended torque.

14B. Enternal Parts (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7)

A. Fits and Clearances

See Figure 405E (Sheets 1 through 4), Figure 405F (Sheets 1 through 4) and Figure 405G (Sheets 1 through 4).

REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMTS MIN	LIMTS MAX	REPLACE IF OVER
1900	B	Fuel De-Icing Filter Cover Mounting Spacer			.001	.005	.007
1901	B	Fuel De-Icing Filter Cover Link Mount Spacer			.001	.005	.007
1902	B	Fuel De-Icing Filter Link Spacer			.0015	.0055	.007
1907	B	Intermediate Case Bolt	.5932 .5792	.5942 .5832	.010	.015	.020

REF. NO.	OIR	DESCRIPTION	REF. DIM. MIM	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
1908	B	Oil Pressure & Drain Adapter Bolt					
		Sleeve Spacer	.5932	.5992			
		Bolt	.5792	.5832	.010	.020	.025
1909	B	Main Oil Filter					
		Housing	.7122	.7142			
		Spacer	.7092	.7112	.001	.005	.007
1910	B	Oil Pressure & Drain					
		Adapter	.7122	.7142			
		Spacer	.7092	.7112	.001	.005	.007
1911	B	Fuel Heater Lower					
		Bracket	.374	.376			
		Bracket Sleeve Spacer	.371	.373	.001	.005	.007
1912	D	Gap Anti-Icing Tube Coupling Assy. (Select Gasket to Obtain)			.020		
1913	B	Bend Cup Assy. Edge Lip must contact Company Name Plate Securely All Around					
		Minimum clearance between tubes (except where clipped together) and also between tubes and engine case should be 0.125 inch unless otherwise specified.					
1975		Fuel Control to PD Valve Sensing Tube Assy. Condensation Trap Tube Nut			.070		

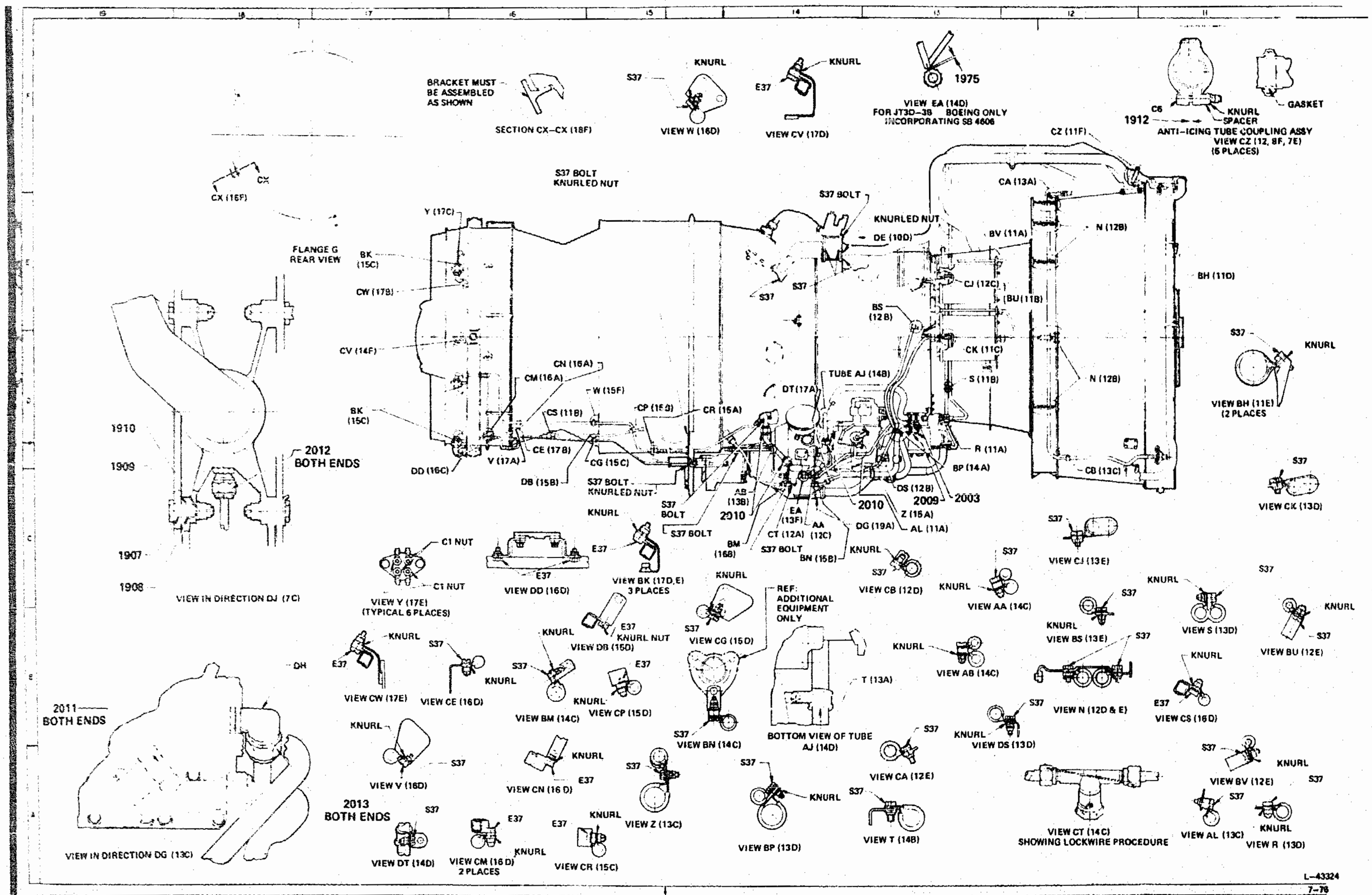
B. Torque Limits

REF. NO.	OIR	DESCRIPTION	LIMITS MIN	LIMITS MAX
2001	A	Compressor Bleed Actuator Screen Housing Connector	400	450
2002	A	Oil Tank Plug	200	250
2003	A	Tube Connector	525	625

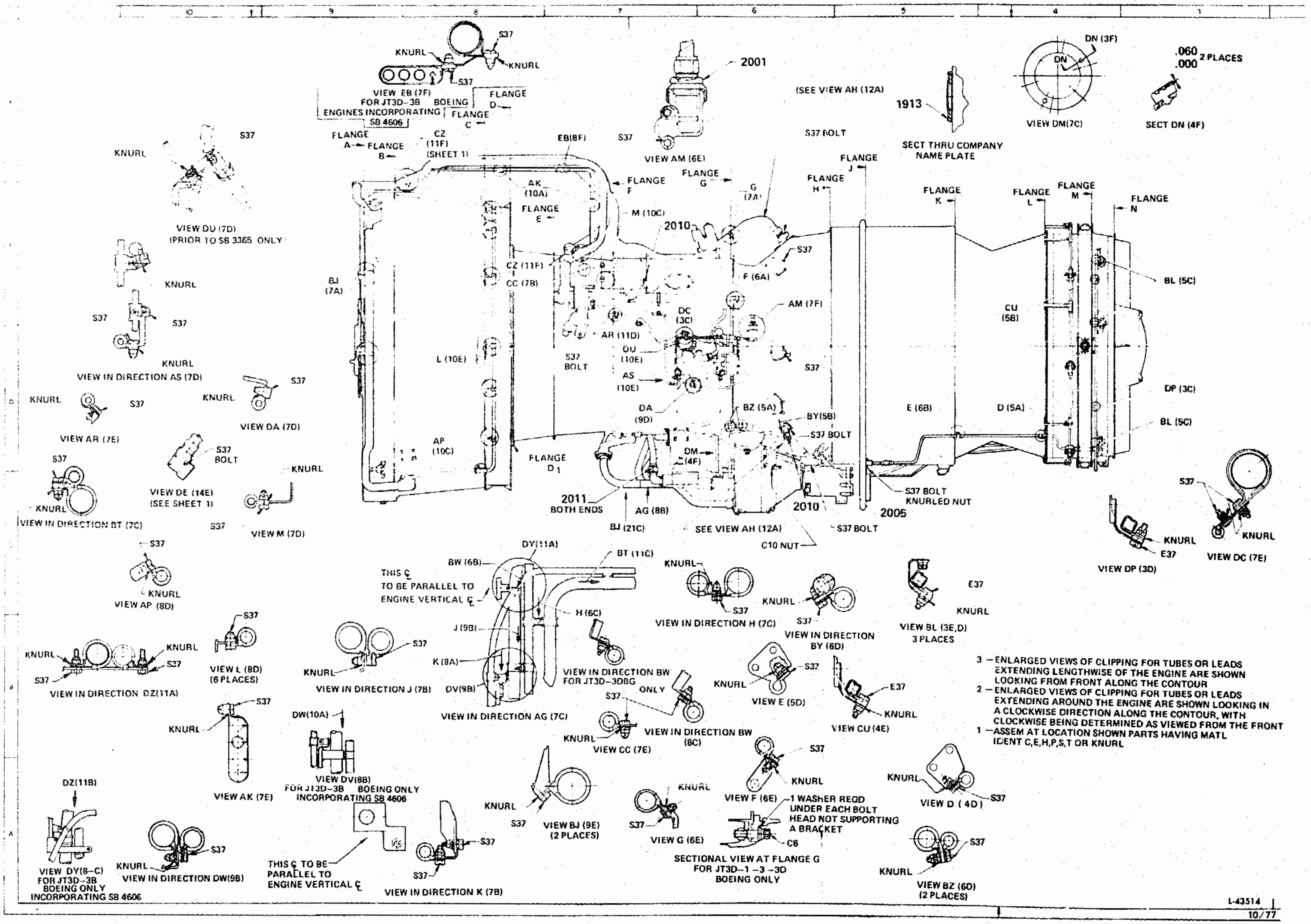
ENGINE - DISMANTLING/ASSEMBLY

REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
2004	A	Oil Tank Mounting Bracket Nuts					
		NOTE: Tighten until just before nut begins to tension strap. Check torque at this point; then continue to tighten until 5-7 pound inches above previously check torque is reached.					
2005	A	Sparkigniter			300	360	
2006	A	Thermocouple Terminal Box Nut			30	35	
2009	A	Flexible Tube Connector			200	220	
2010	A	Flexible Tube Connection			140	160	
	A	Tube Connector (JT3D-1-MC6 Boeing)			525	625	
2011	A	Flexible Tube Connections (JT3D-1,D-3, D-3B and MC6 Qantas)			160	175	
2012	A	Flexible Tube Connections			60	65	
2013	A	Flexible Tube Connections (JT3D-1,D-3, D-3B and MC6 Qantas)			120	130	
	A	Flexible Tube Connections (JT3D-1MC6 and MC7)			140	160	
2014	A	Flexible Tube Connections (JT3D-1-MC6 and MC7)			160	175	
2015	A	Flexible Tube Connections (JT3D-1-MC6 and MC7)			60	65	
2016	A	Flexible Tube Connections (JT3D-1-MC6 and MC7)			120	130	

NOTE: Fits and Clearances for other external parts may also be found in applicable major assembly fits and clearances section.



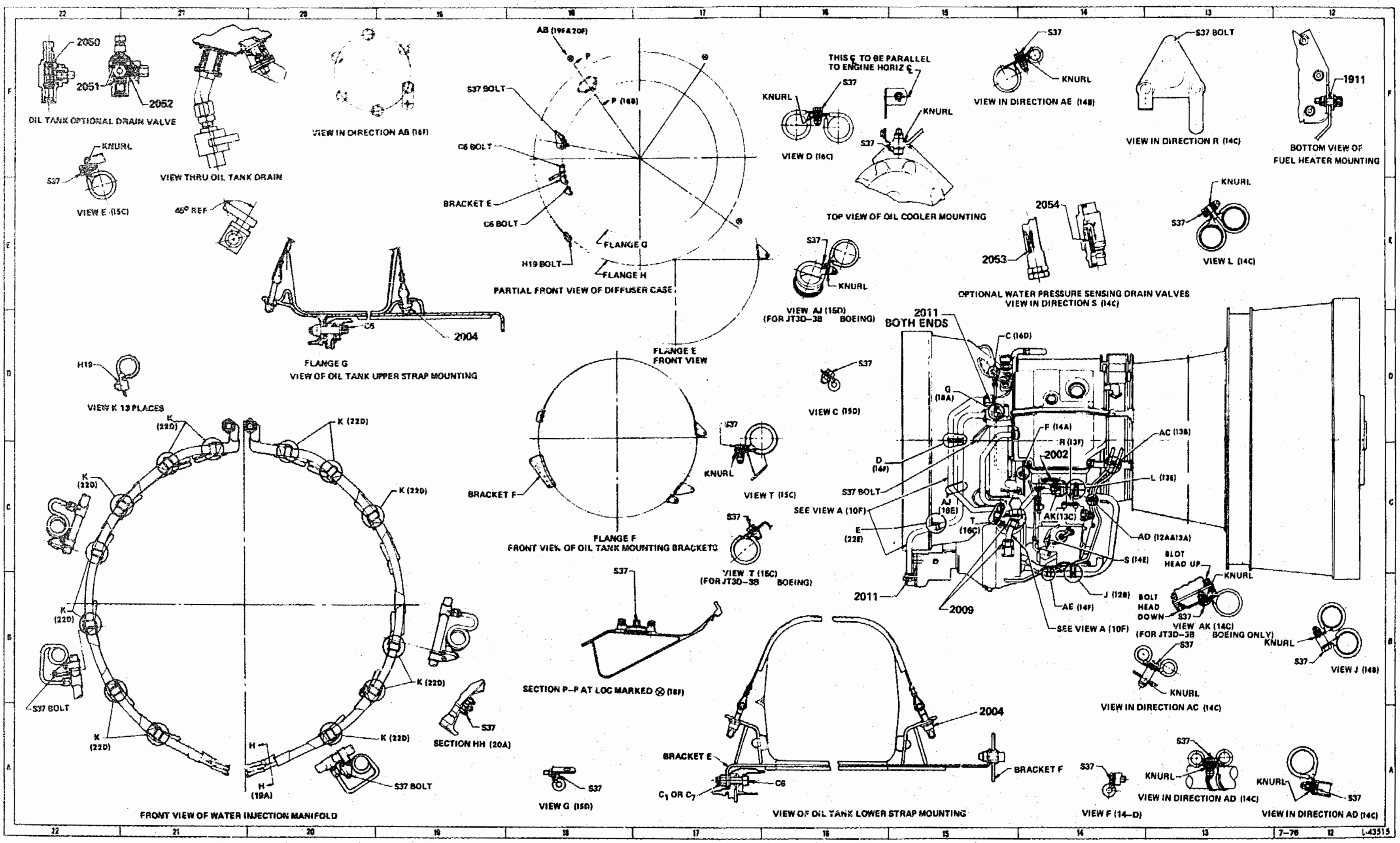
External Parts (JT3D-1 Boeing,
JT3D-3 Boeing, JT3D-3B Boeing And
JT3D-1-MC6 QANTAS)
Figure 405E (Sheet 1)



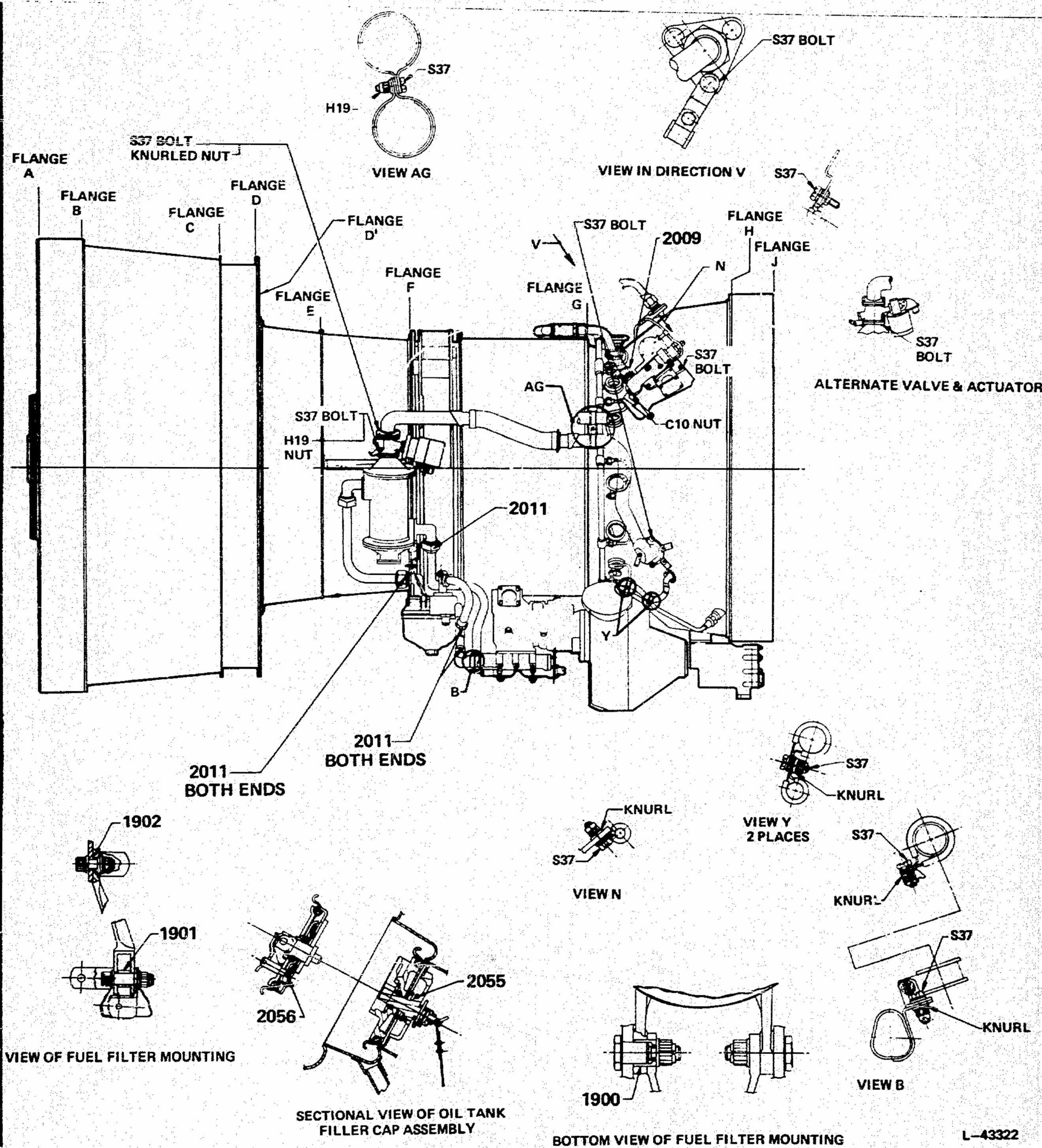
External Parts (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing And JT3D-1-MC6 QANTAS)

Figure 405E (Sheet 2)

ENGINE - DISMANTLING/ASSEMBLY

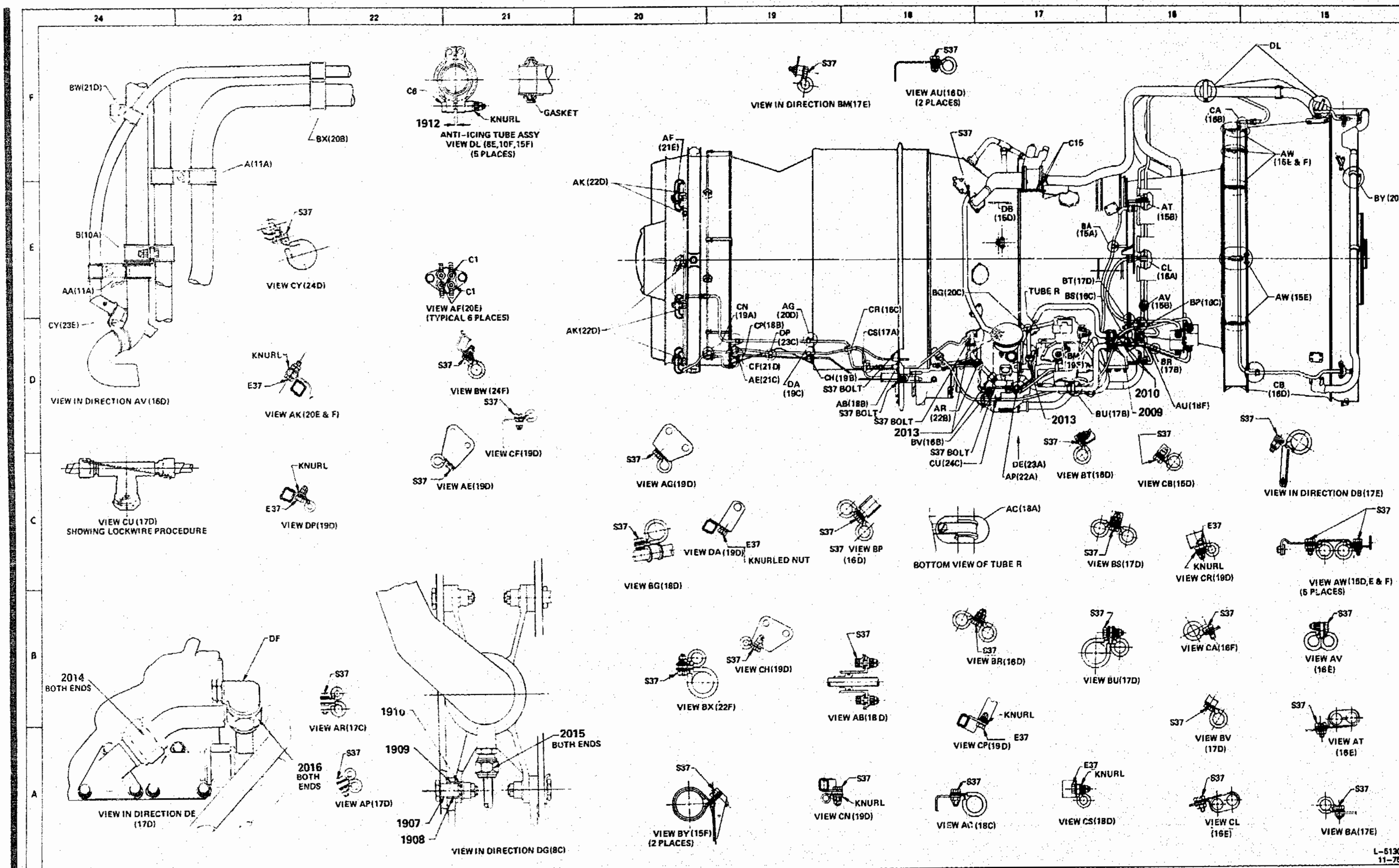


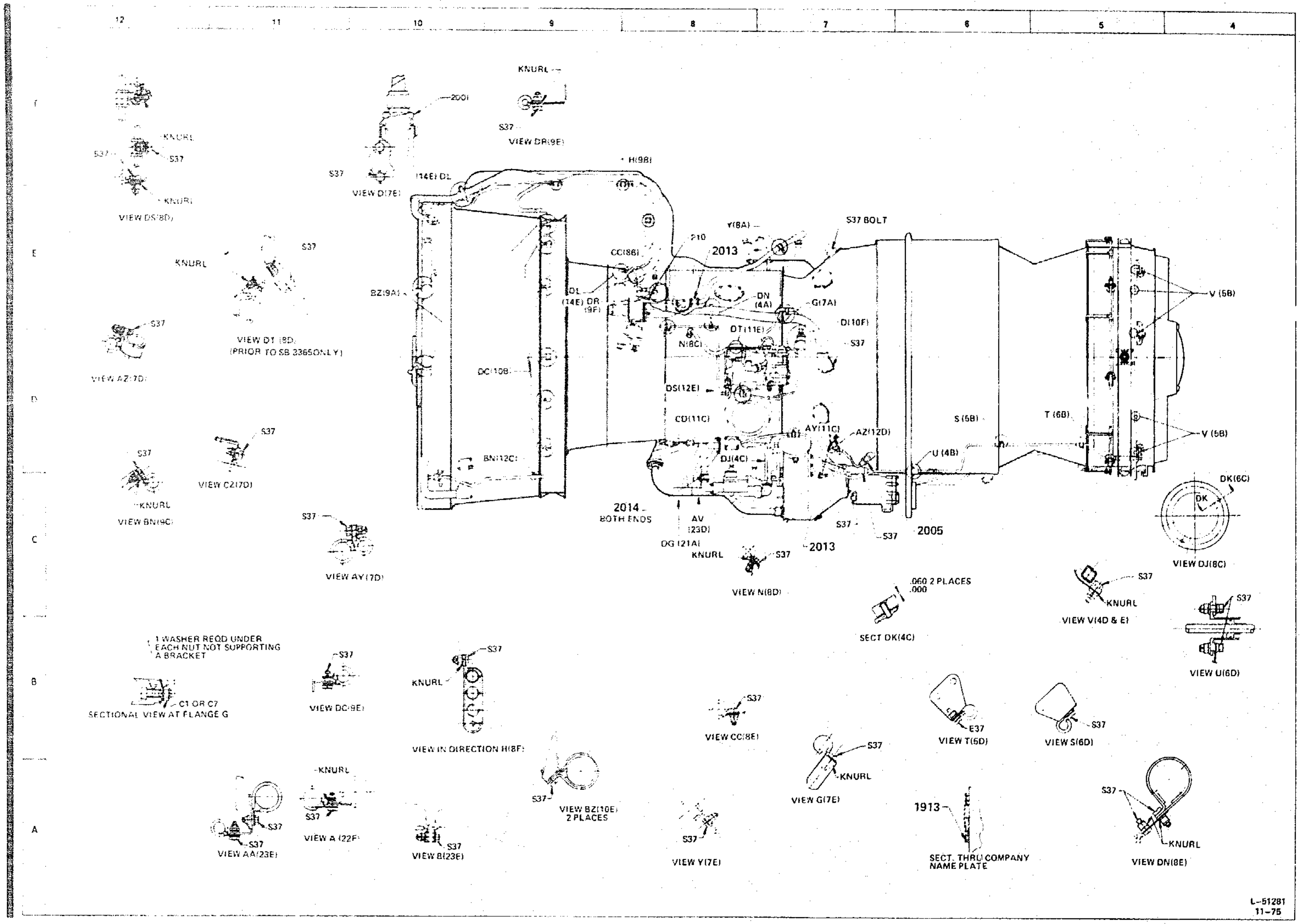
External Parts (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing And JT3D-1-MC6 QANTAS)
Figure 405E (Sheet 3)



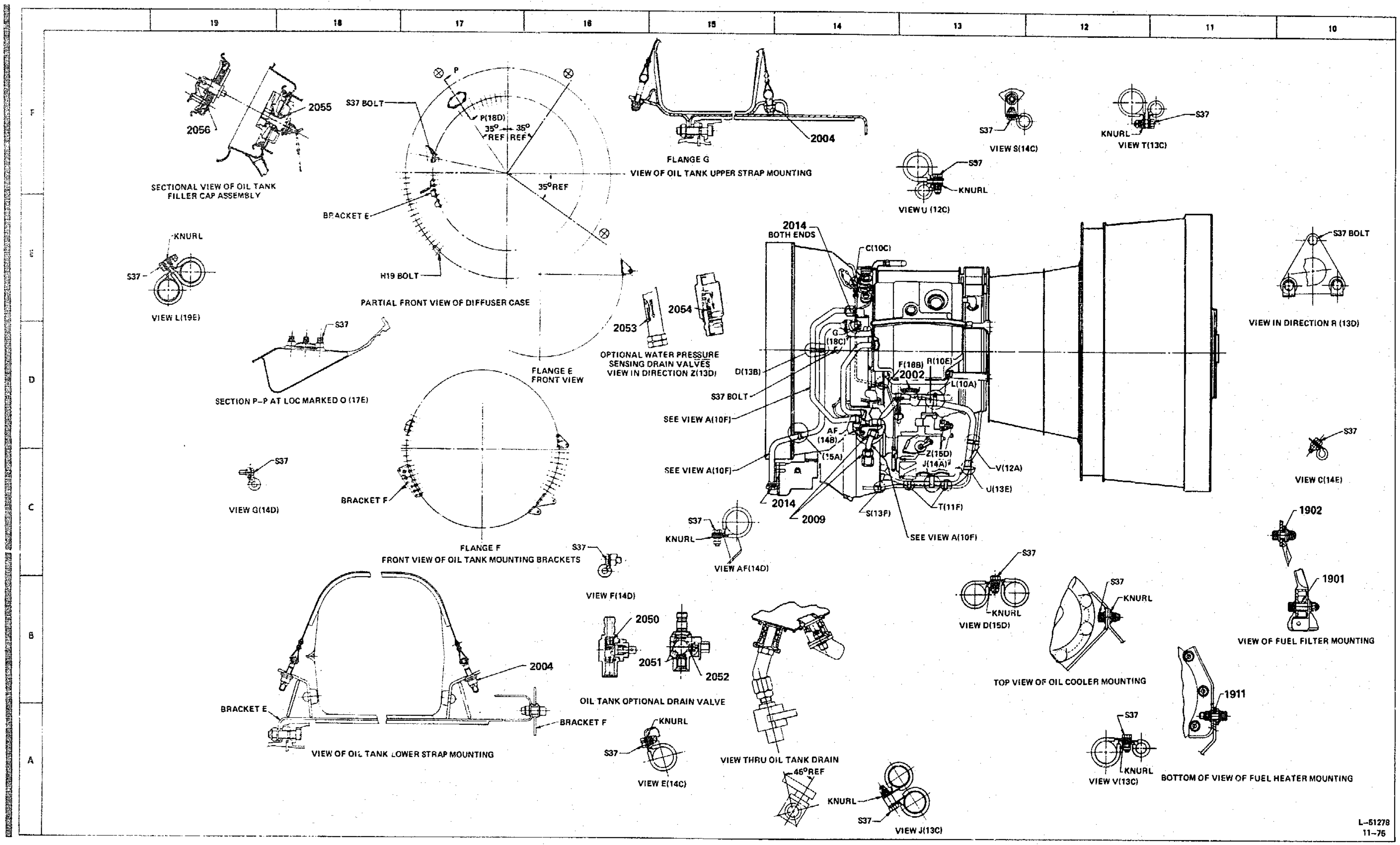
External Parts (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing And JT3D-1-MC6 QANTAS)

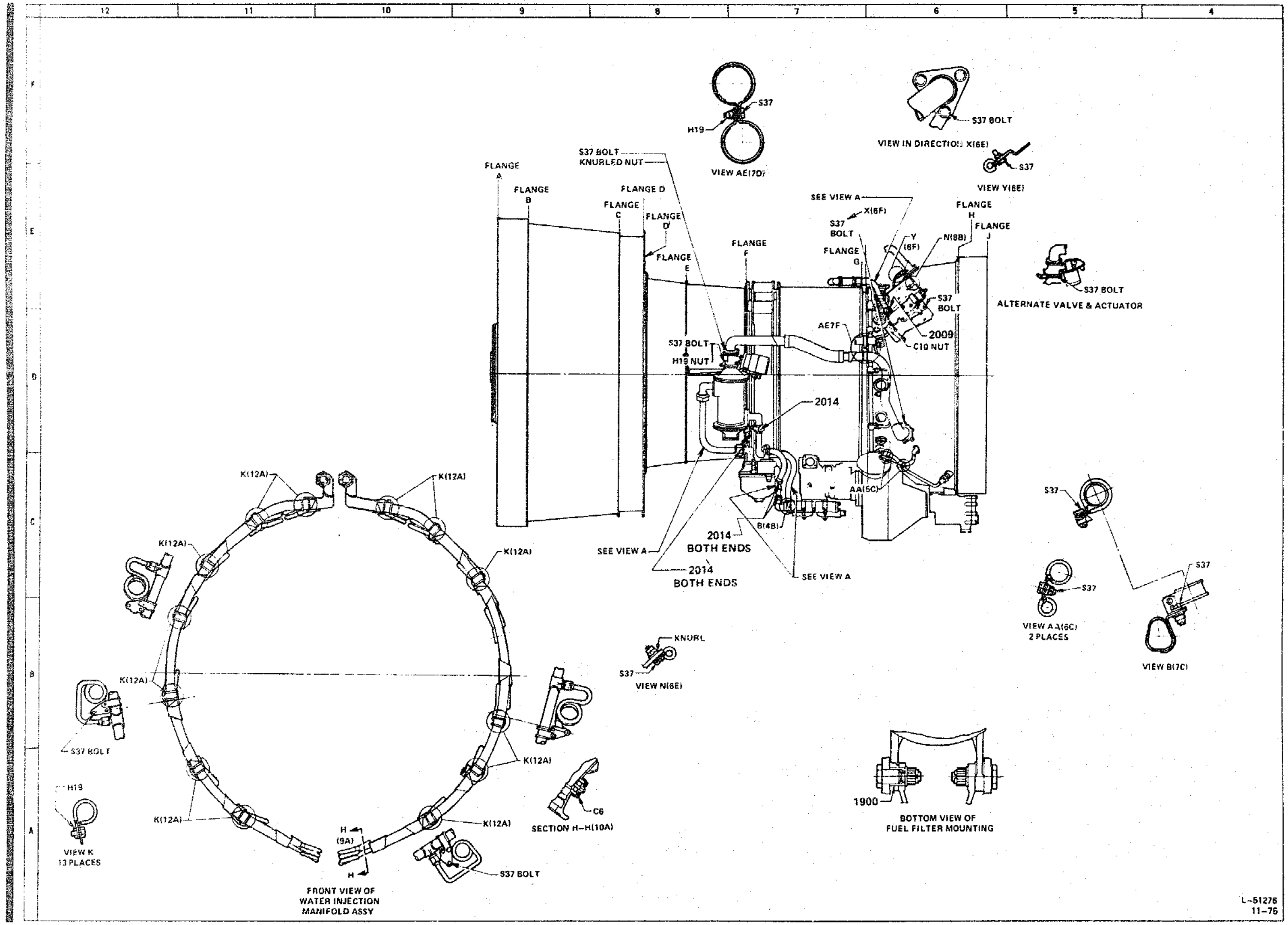
ENGINE - DISMANTLING/ASSEMBLY

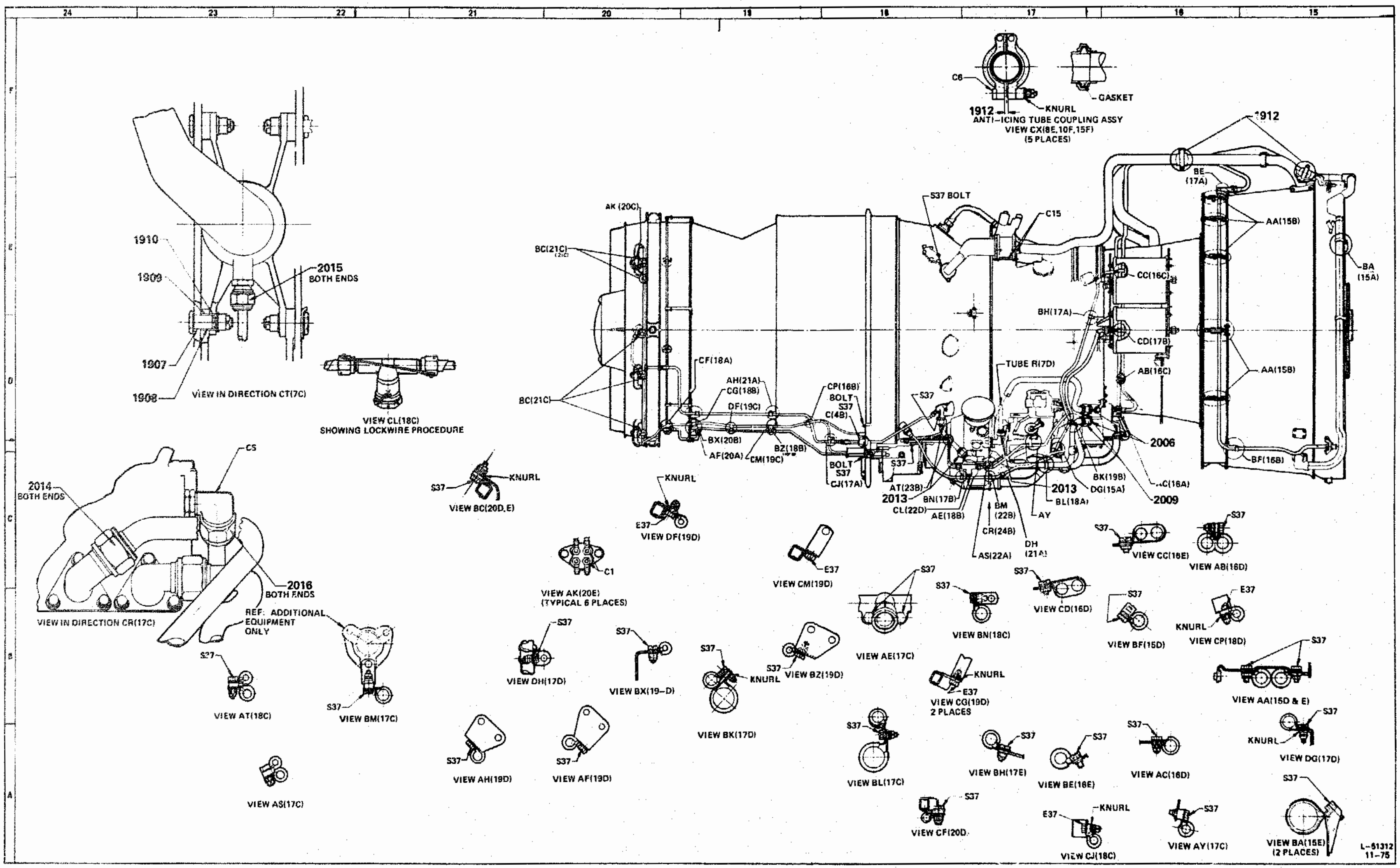


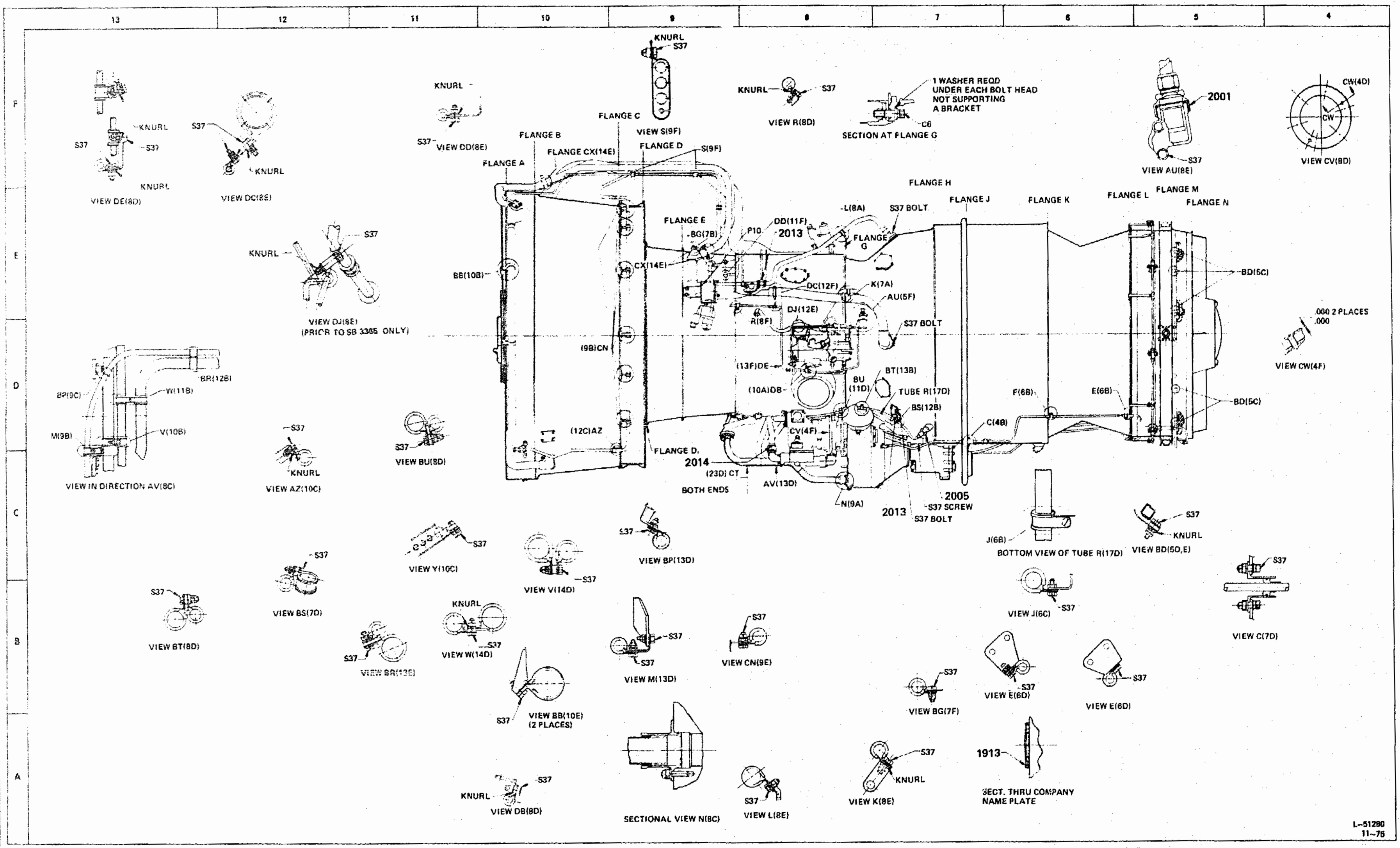


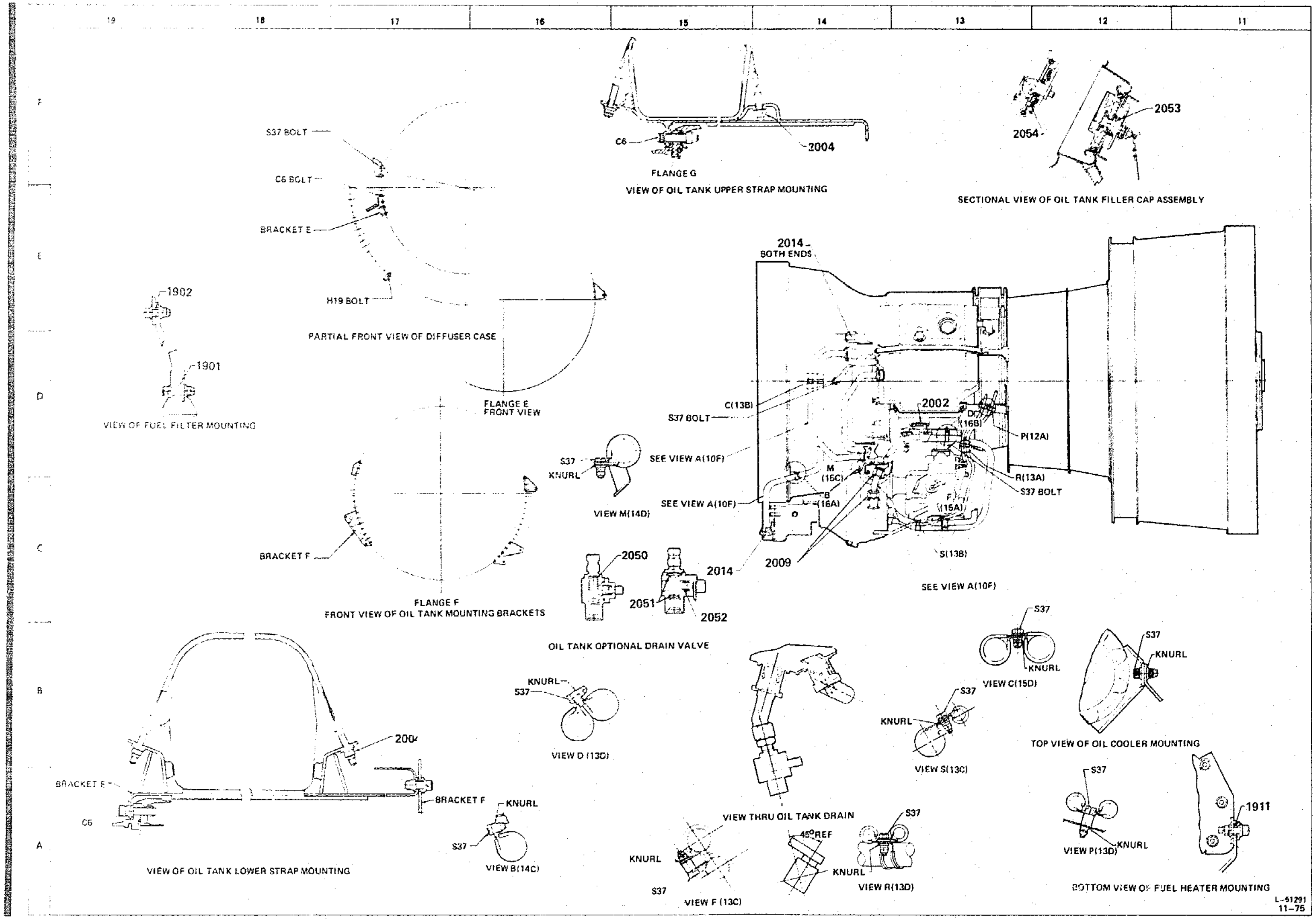
External Parts (JT3D-1-MC6 Boeing)
Figure 405F (Sheet 2) (CJ-2)

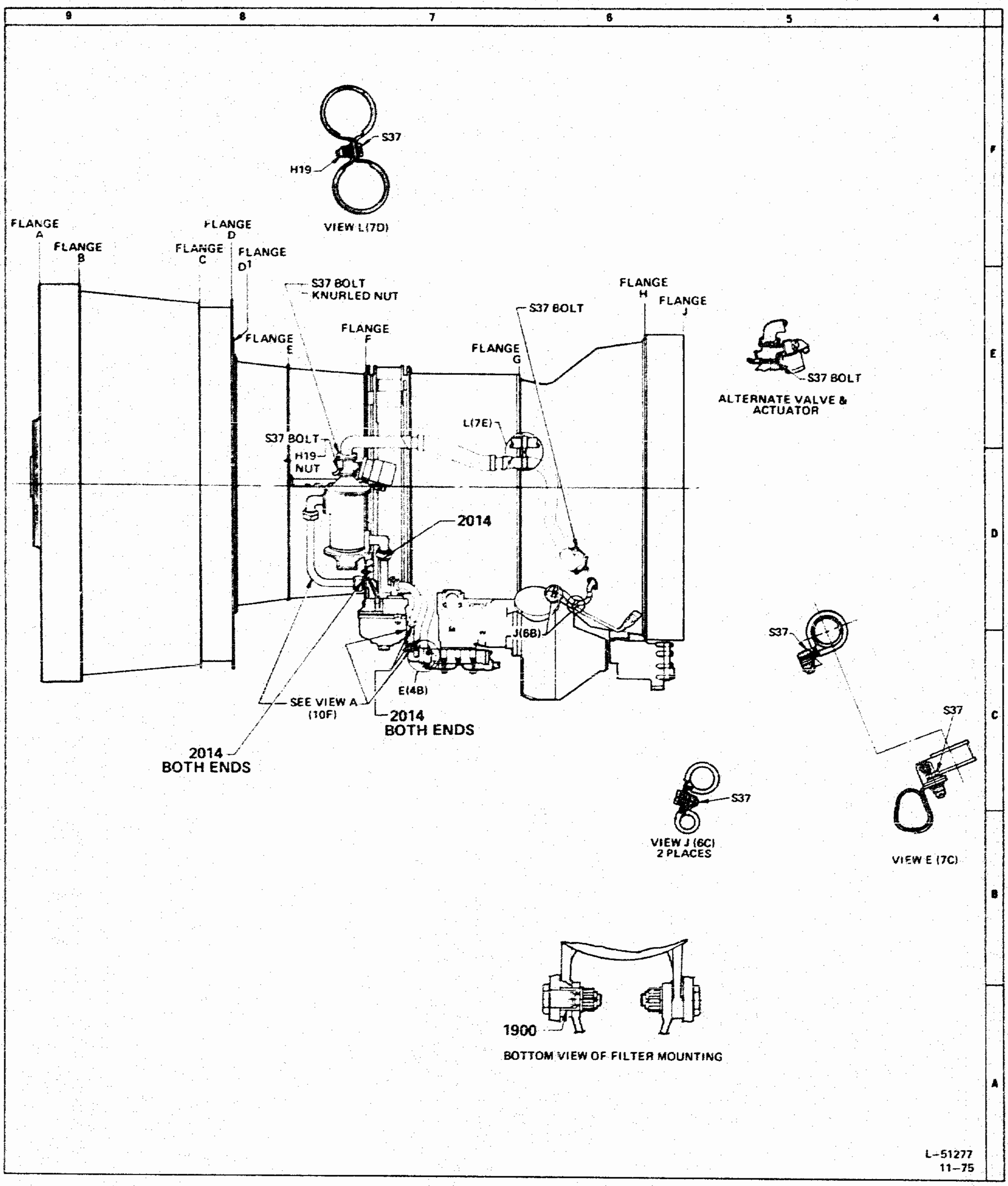

19
18
17
16
15
14
13
12
11
10
F
E
D
C
B
A
2055
2056
SECTIONAL VIEW OF OIL TANK FILLER CAP ASSEMBLY
S37 BOLT
P(18D)
35° REF
35° REF
35°REF
BRACKET E
H19 BOLT
PARTIAL FRONT VIEW OF DIFFUSER CASE
2004
FLANGE G
VIEW OF OIL TANK UPPER STRAP MOUNTING
S37
VIEW S(14C)
KNURL
VIEW T(13C)
VIEW U (12C)
KNURL
S37
VIEW L(19E)
2053
2054
OPTIONAL WATER PRESSURE SENSING DRAIN VALVES VIEW IN DIRECTION Z(13D)
FLANGE E FRONT VIEW
SECTION P–P AT LOC MARKED O (17E)
2014 BOTH ENDS
C(10C)
G (18C)
D(13B)
F(18B)
R(10E)
2002
L(10A)
S37 BOLT
SEE VIEW A(10F)
AF (14B)
(15A)
Z(15D)
J(14A)
V(12A)
U(13E)
T(11F)
S(13F)
2014
2009
SEE VIEW A(10F)
VIEW IN DIRECTION R (13D)
VIEW C(14E)
VIEW G(14D)
BRACKET F
FLANGE F
FRONT VIEW OF OIL TANK MOUNTING BRACKETS
VIEW F(14D)
VIEW AF(14D)
1902
1901
VIEW OF FUEL FILTER MOUNTING
VIEW D(15D)
TOP VIEW OF OIL COOLER MOUNTING
2050
2051
2052
OIL TANK OPTIONAL DRAIN VALVE
VIEW OF OIL TANK LOWER STRAP MOUNTING
VIEW E(14C)
VIEW THRU OIL TANK DRAIN
46°REF
VIEW J(13C)
VIEW V(13C)
1911
BOTTOM OF VIEW OF FUEL HEATER MOUNTING
L-51278
11-76


S37
H19
VIEW AE(7D)
S37 BOLT
VIEW IN DIRECTION X(6E)
S37
VIEW Y(6E)
S37 BOLT
KNURLED NUT
FLANGE A
FLANGE B
FLANGE C
FLANGE D
FLANGE D'
FLANGE E
FLANGE F
FLANGE G
FLANGE H
FLANGE J
SEE VIEW A
X(6F)
S37 BOLT
Y (6F)
N(8B)
S37 BOLT
ALTERNATE VALVE & ACTUATOR
S37 BOLT
AE7F
2009
C10 NUT
S37 BOLT
H19 NUT
2014
AA(5C)
B(4B)
2014 BOTH ENDS
SEE VIEW A
2014 BOTH ENDS
SEE VIEW A
K(12A)
S37
S37
S37
VIEW AA(6C) 2 PLACES
VIEW B(7C)
KNURL
S37
VIEW N(6E)
S37 BOLT
H19
VIEW K 13 PLACES
H (9A) H
C6
SECTION H-H(10A)
S37 BOLT
FRONT VIEW OF WATER INJECTION MANIFOLD ASSY
1900
BOTTOM VIEW OF FUEL FILTER MOUNTING
L-51276 11-75


ANTI-ICING TUBE COUPLING ASSY
VIEW CX(8E,10F,15F)
(5 PLACES)
VIEW IN DIRECTION CT(7C)
VIEW CL(18C)
SHOWING LOCKWIRE PROCEDURE
VIEW IN DIRECTION CR(17C)
REF: ADDITIONAL EQUIPMENT ONLY
VIEW BC(20D,E)
VIEW DF(19D)
VIEW AK(20E)
(TYPICAL 6 PLACES)
VIEW CM(19D)
VIEW AT(18C)
VIEW BM(17C)
VIEW AS(17C)
VIEW DH(17D)
VIEW BX(19-D)
VIEW BK(17D)
VIEW BZ(19D)
VIEW AH(19D)
VIEW AF(19D)
VIEW AE(17C)
VIEW BN(18C)
VIEW CG(19D)
2 PLACES
VIEW BL(17C)
VIEW CF(20D)
VIEW CC(16E)
VIEW AB(16D)
VIEW CD(16D)
VIEW BF(15D)
VIEW CP(18D)
VIEW AA(15D & E)
VIEW DG(17D)
VIEW BH(17E)
VIEW BE(16E)
VIEW AC(16D)
VIEW CJ(18C)
VIEW AY(17C)
VIEW BA(15E)
(2 PLACES)
L-51312
11-75


VIEW DE(8D)
VIEW DC(8E)
VIEW DD(8E)
VIEW S(9F)
VIEW R(8D)
1 WASHER REQD UNDER EACH BOLT HEAD NOT SUPPORTING A BRACKET
SECTION AT FLANGE G
2001
VIEW AU(8E)
VIEW CV(8D)
FLANGE A
FLANGE B
FLANGE C
FLANGE D
FLANGE E
FLANGE G
FLANGE H
FLANGE J
FLANGE K
FLANGE L
FLANGE M
FLANGE N
2013
2014
2005
1913
VIEW DJ(8E) (PRIOR TO SB 3365 ONLY)
VIEW CW(4F)
VIEW IN DIRECTION AV(8C)
VIEW AZ(10C)
VIEW BU(8D)
BOTH ENDS
BOTTOM VIEW OF TUBE R(17D)
VIEW BD(5D,E)
VIEW Y(10C)
VIEW V(14D)
VIEW BP(13D)
VIEW BS(7D)
VIEW BT(8D)
VIEW J(6C)
VIEW C(7D)
VIEW W(14D)
VIEW BR(12E)
VIEW M(13D)
VIEW CN(9E)
VIEW BG(7F)
VIEW E(6D)
VIEW BB(10E) (2 PLACES)
SECTIONAL VIEW N(8C)
VIEW L(8E)
VIEW K(8E)
SECT. THRU COMPANY NAME PLATE
VIEW DB(8D)
L-51280 11-76


S37 BOLT
C6 BOLT
BRACKET E
H19 BOLT
PARTIAL FRONT VIEW OF DIFFUSER CASE
FLANGE E FRONT VIEW
C6
2004
FLANGE G
VIEW OF OIL TANK UPPER STRAP MOUNTING
2053
2054
SECTIONAL VIEW OF OIL TANK FILLER CAP ASSEMBLY
1902
1901
VIEW OF FUEL FILTER MOUNTING
2014 BOTH ENDS
C(13B)
S37 BOLT
2002
D(16B)
P(12A)
SEE VIEW A(10F)
M (15C)
B (16A)
R(13A)
S37 BOLT
F (15A)
S37
KNURL
VIEW M(14D)
BRACKET F
FLANGE F
FRONT VIEW OF OIL TANK MOUNTING BRACKETS
2050
2051
2014
2052
2009
S(13B)
OIL TANK OPTIONAL DRAIN VALVE
VIEW C(15D)
TOP VIEW OF OIL COOLER MOUNTING
VIEW D (13D)
VIEW S(13C)
BRACKET E
C6
BRACKET F
VIEW OF OIL TANK LOWER STRAP MOUNTING
VIEW B(14C)
VIEW THRU OIL TANK DRAIN
45° REF
VIEW F (13C)
VIEW R(13D)
VIEW P(13D)
1911
BOTTOM VIEW OF FUEL HEATER MOUNTING
L-51291
11-75



External Parts (JT3D-1-MC7)
Figure 405G (Sheet 4) (AE-3)

ENGINE - DISMANTLING/ASSEMBLY

14C. External Parts (JT3D-1 Douglas, JT3D-3 Douglas, JT3D-3B Douglas, JT3D-3B-DL)

A. Fits and Clearances

See Figure 405H (Sheets 1 through 6) and Figure 405I (Sheets 1 through 6).

REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
1902	A	Power Lever Linkage Bearing Housing Bracket Bearing Housing			.000	.002	.003
1903	A	Power Lever Arm Airframe Ball Bearing			.000	.002	.002
1903A	A	Power Lever Arm - Sleeve Type Bearing			.0025	.0050	
1904	A	Airframe Ball Bearing Power Lever Linkage Bearing Housing			.000	.002	.002
1904A		Power Lever Linkage Bearing Housing - Sleeve Type Bearing			.001T	.001	
1905	A	Power Lever Linkage Bearing Housing - Sleeve Spacer			.002	.004	.005
1908	A	Power Lever Linkage Bearing Housing - Airframe			.000	.002	.002
1908A		Power Lever Linkage Bearing Housing - Sleeve Type Bearing			.0025	.0050	
1909	A	Airframe Ball Bearing - Shutoff Power Lever Arm			.000	.002	.002
1909A		Shutoff Power Lever Arm - Sleeve Type Bearing			.001T	.001	
1913	A	Sleeve Spacer - Shutoff Power Lever Arm			.002	.004	.005

ENGINE - DISMANTLING/ASSEMBLY

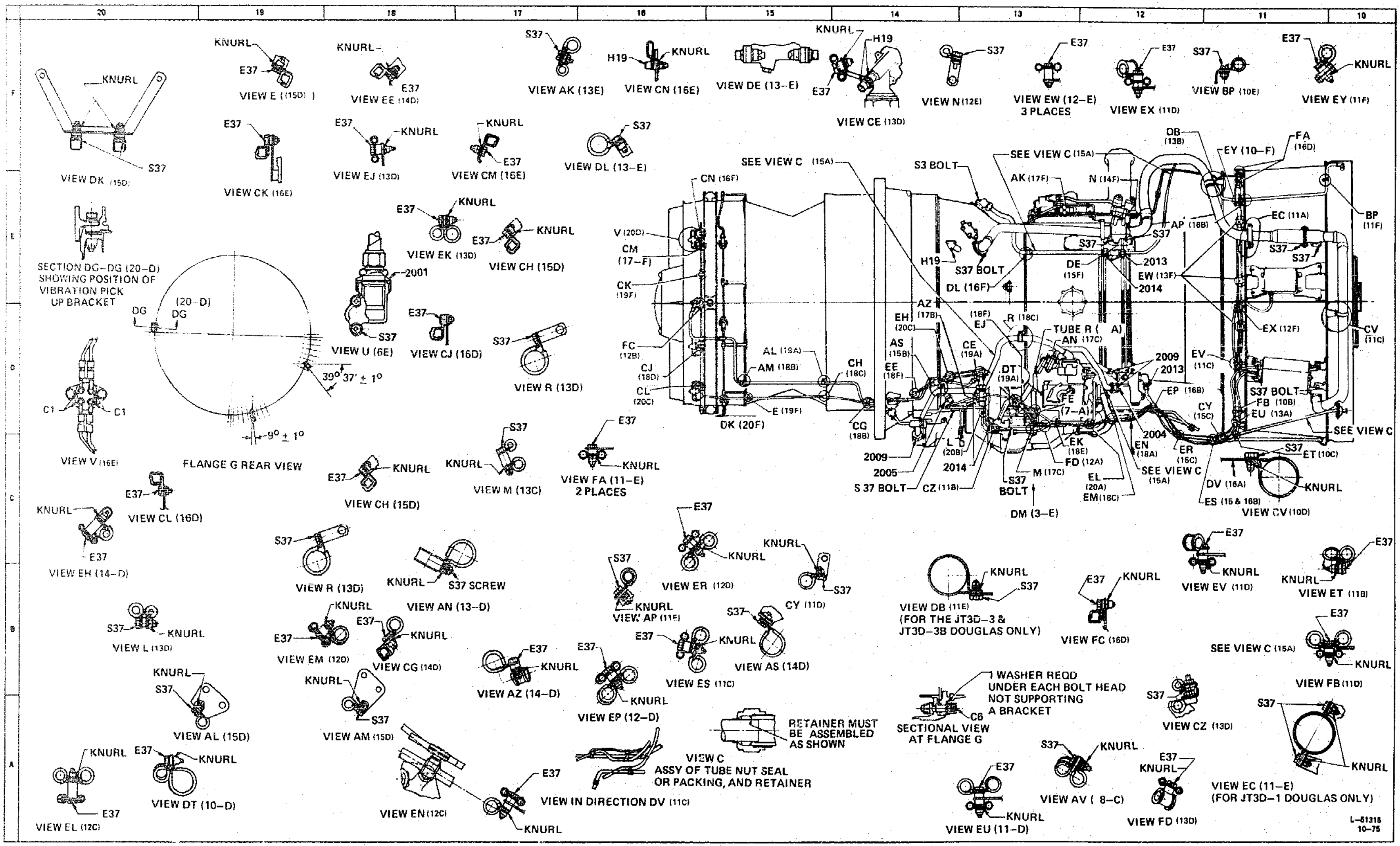
REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
1915	A	Rod Shutoff Lever Clevis - Bolt			.0015	.0025	.0030
1916	A	Annular Ball Bearing - Bolt			.0005	.0015	.0015
1917	A	Power Lever Arm - Annular Ball Bearing			.000	.001T	.000
1918	D	Sleeve Spacer - Bolt			.005	.0075	
1919	D	Intermediate Case - Bolt			.0005	.0025	.0035
1920	D	Sleeve Spacer - Bolt			.0023	.0133	.015
1921	D	Washer - Bolt			.0008	.0088	.010
1922	D	Oil Adapter - Sleeve Spacer			.001	.005	.006
1923	D	Sleeve Spacer - Bolt			.005	.0075	
1924	D	Adapter Oil - Sleeve Spacer			.001	.005	.007
1925	D	Oil Filter - Sleeve Spacer			.0025	.0055	.007
1926	D	Mounting Link Side Clearance			.000	.010	.015
1927	D	Mounting Link - Bolt			.0013	.0043	
1928		Mounting Plate - Washer			.0073	.0103	
1929		Mounting Plate Side Clearance			.000	.010	.015
1931	D	Gap Anti-Icing Tube Coupling Assy (Select Gasket to Obtain)			.020		
1932	B	Oil Tank Inner Bracket Assy. Bushing	.4385	.4395			
		Bracket	.4370	.4380	.0005T	.0025T	

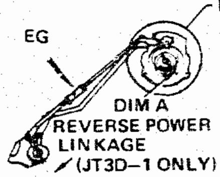
ENGINE - DISMANTLING/ASSEMBLY

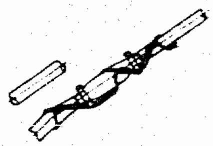
REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
1933	B	Oil Tank Upper And Lower Bracket Pin	.303	.304			
		Oil Tank Inner Bracket Assy. Bushing	.306	.311	.002	.008	
1934	B	Oil Tank Upper and Lower Bracket Assy.					
		Pin	.303	.304			
		Bracket	.3015	.3025	.0005T	.0025T	
1935	B	Bend Cup Assy. Edge Lip Must Contact Company Name Plate Securely All Around					
		B. Torque Limits					
2001	A	Compressor Bleed Actuator Screen Housing Connector			400	450	
2002	A	Oil Tank Mounting Bracket Nuts			5	7	
2003	B	Oil Tank Drain Valve Spring At 270° CCW Turn			2.800	3.500	
2004	A	Tube Connector			525	625	
2005	A	Igniter Plug			300	360	
2006	A	Thermocouple Terminal Box Nut			30	35	
2009	A	Flexible Tube Connection			200	220	
2013	A	Flexible Tube Connection			110	120	
2014	A	Flexible Tube Connection			140	160	
2015	A	Housing Power Lever Linkage Bearing Retaining Nut			150	200	
2016	A	Flexible Tube Connections			160	175	

ENGINE - DISMANTLING/ASSEMBLY

REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
2017	A	Flexible Tube Connections			60	65	
2018	A	Flexible Tube Connections			120	130	
2019	A	Arm Shutoff Power Lever Retaining Nut			100	150	
2020	A	Clevis Rod End Shutoff Lever Bolt			25	75	
2021		Thermocouple Harness-to-Retaining Nut 164-32			12	15	
2022		Thermocouple Harness-to-Retaining Nut 190-32			12	15	


20
19
18
17
16
15
14
13
12
11
10
KNURL
S37
VIEW DK (15D)
KNURL
E37
VIEW E (15D)
KNURL
E37
VIEW EE (14D)
S37
VIEW AK (13E)
H19
KNURL
VIEW CN (16E)
VIEW DE (13–E)
KNURL
H19
E37
VIEW CE (13D)
S37
VIEW N (12E)
E37
VIEW EW (12–E)
3 PLACES
E37
VIEW EX (11D)
S37
VIEW BP (10E)
E37
KNURL
VIEW EY (11F)
E37
VIEW CK (16E)
E37
KNURL
VIEW EJ (13D)
KNURL
E37
VIEW CM (16E)
S37
VIEW DL (13–E)
SECTION DG–DG (20–D)
SHOWING POSITION OF
VIBRATION PICK
UP BRACKET
(20–D)
DG
DG
39° 37' ± 1°
9° ± 1°
FLANGE G REAR VIEW
C1
C1
VIEW V (16E)
E37
KNURL
VIEW EK (13D)
E37
KNURL
VIEW CH (15D)
2001
S37
VIEW U (6E)
E37
VIEW CJ (16D)
S37
VIEW R (13D)
SEE VIEW C (15A)
CN (16F)
V (20D)
CM (17–F)
CK (19F)
FC (12B)
CJ (18D)
CL (20C)
DK (20F)
E (19F)
AL (19A)
AM (18B)
CH (18C)
CG (18B)
S3 BOLT
SEE VIEW C (15A)
AK (17F)
N (14F)
DB (13B)
EY (10–F)
FA (16D)
BP (11F)
AP (16B)
EC (11A)
S37
H19
S37 BOLT
DL (16F)
DE (15F)
2013
EW (13F)
2014
EX (12F)
CV (11C)
AZ (17B)
EH (20C)
AS (15B)
EE (18F)
R (18C)
EJ
CE (19A)
DT (19A)
TUBE R (A)
AN (17C)
FE (7–A)
2009
2013
EV (11C)
EP (16B)
CY (15C)
S37 BOLT
FB (10B)
EU (13A)
SEE VIEW C
2009
2005
S 37 BOLT
L D (20B)
2014
CZ (11B)
S37 BOLT
M (17C)
EK (18E)
FD (12A)
EL (20A)
EM (18C)
2004
EN (18A)
ER (15C)
SEE VIEW C (15A)
DV (16A)
ES (16 & 16B)
ET (10C)
KNURL
VIEW CV (10D)
DM (3–E)
KNURL
E37
VIEW EH (14–D)
E37
VIEW CL (16D)
E37
KNURL
VIEW CH (15D)
KNURL
VIEW M (13C)
E37
KNURL
VIEW FA (11–E)
2 PLACES
S37
VIEW R (13D)
KNURL
S37 SCREW
VIEW AN (13–D)
E37
KNURL
VIEW ER (12D)
S37
KNURL
VIEW AP (11F)
KNURL
S37
CY (11D)
KNURL
S37
VIEW DB (11E)
(FOR THE JT3D–3 &
JT3D–3B DOUGLAS ONLY)
E37
KNURL
VIEW FC (16D)
E37
KNURL
VIEW EV (11D)
E37
KNURL
VIEW ET (11B)
S37
KNURL
VIEW L (13D)
KNURL
E37
VIEW EM (12D)
E37
KNURL
VIEW CG (14D)
E37
KNURL
VIEW AZ (14–D)
E37
KNURL
VIEW EP (12–D)
E37
KNURL
VIEW ES (11C)
S37
KNURL
VIEW AS (14D)
E37
SEE VIEW C (15A)
KNURL
VIEW FB (11D)
KNURL
S37
VIEW AL (15D)
KNURL
S37
VIEW AM (15D)
RETAINER MUST
BE ASSEMBLED
AS SHOWN
1 WASHER REQD
UNDER EACH BOLT HEAD
NOT SUPPORTING
A BRACKET
C6
SECTIONAL VIEW
AT FLANGE G
S37
VIEW CZ (13D)
S37
KNURL
VIEW EC (11–E)
(FOR JT3D–1 DOUGLAS ONLY)
KNURL
E37
VIEW EL (12C)
E37
KNURL
VIEW DT (10–D)
VIEW EN (12C)
E37
KNURL
VIEW IN DIRECTION DV (11C)
VIEW C
ASSY OF TUBE NUT SEAL
OR PACKING, AND RETAINER
E37
KNURL
VIEW EU (11–D)
S37
KNURL
VIEW AV (8–C)
E37
KNURL
VIEW FD (13D)
L-61315
10-75





VIEW IN DIRECTION EG
SHOWING LOCKWIRE PROCEDURE

FUEL CONTROL SHUT-OFF
LINKAGE ADJUSTMENT PROCEDURE

1- SET ADJUSTING SCREWS FLUSH WITH STOPS ON STUB SHAFT
2- ADJUST STUB SHAFT LEVER ON ROD SO THAT THE GAPS BETWEEN LEVER ARM & STOPS IN BOTH DIRECTIONS ARE APPROX EQUAL WHEN THE LEVER ARM ON THE FUEL CONTROL RESTS AGAINST ITS STOPS
3- TURN IN ADJUSTING SCREWS UNTIL THEY CONTACT THE STUB SHAFT LEVER ARM
4- TURN SCREWS ONE ADDITIONAL TURN INWARD

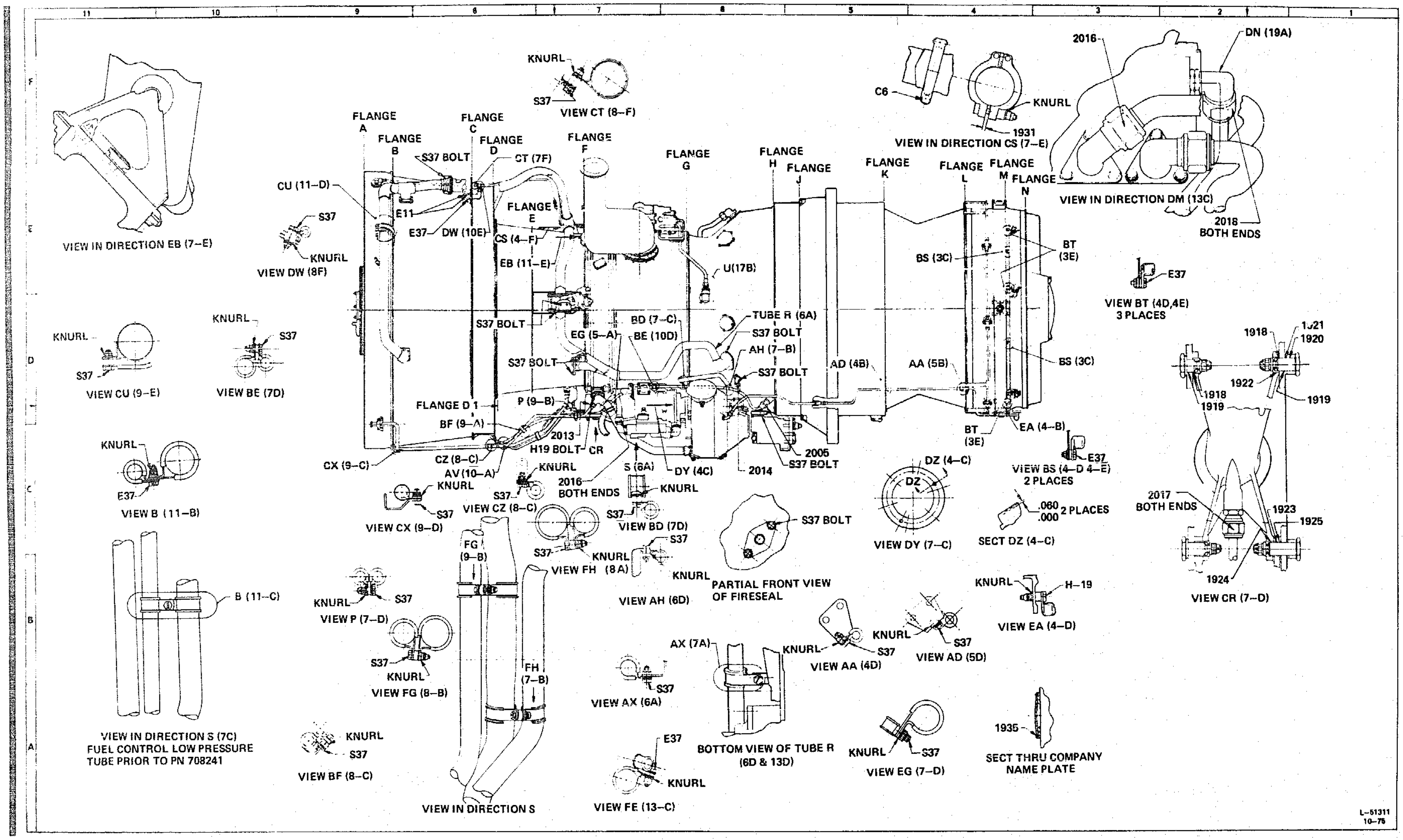
FUEL CONTROL
LINKAGE ADJUSTMENT PROCEDURE

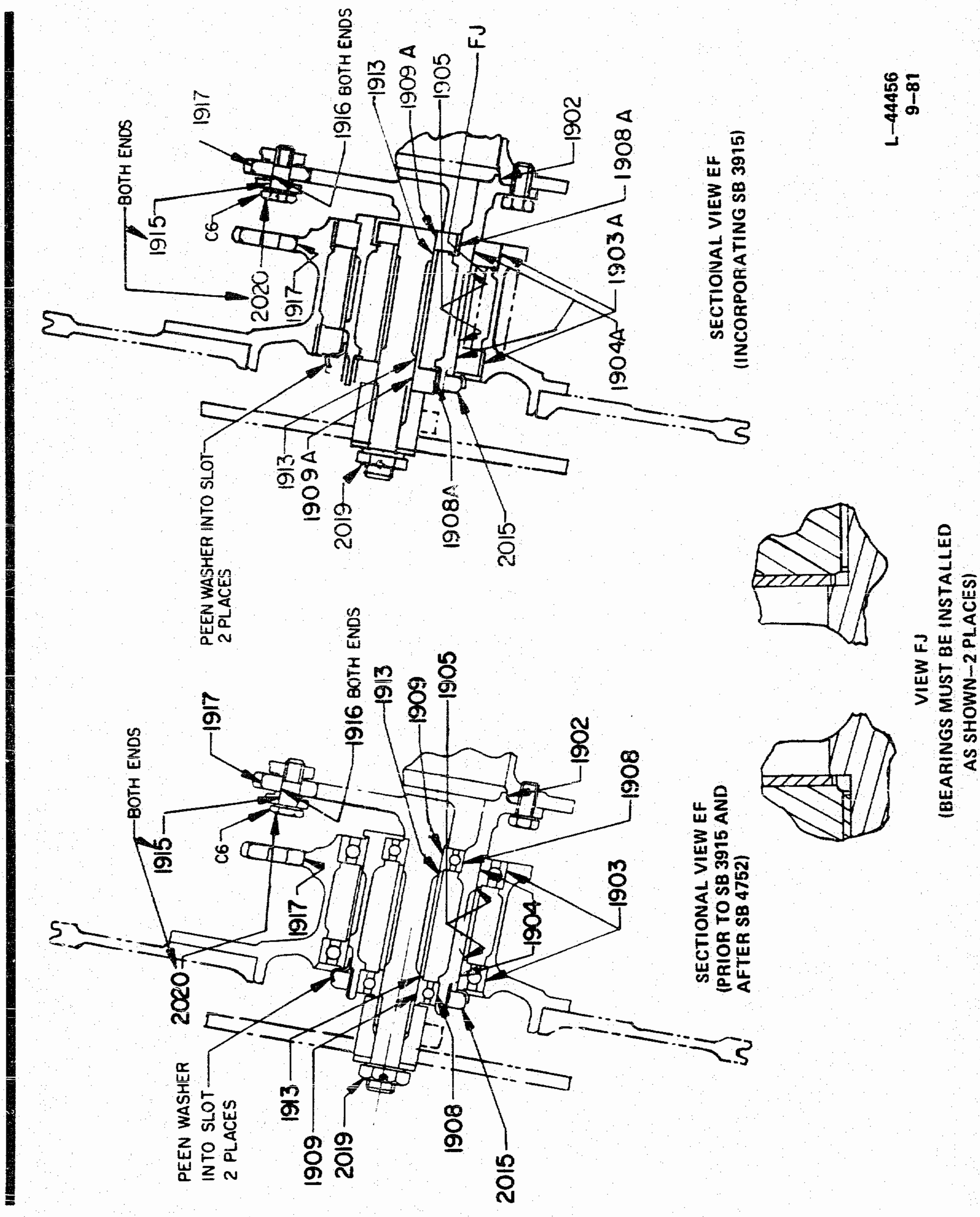
1- MEASURE DISTANCE BETWEEN AXIS OF FUEL CONTROL LEVER & AXIS OF STUBSHAFT LEVER (DIM A LOC B14)
2- ADJUST TURNBUCKLE SO THE DISTANCE BETWEEN END HOLES IS EQUAL WITHIN .005 TO THE DISTANCE MEASURED IN STEP 1
3- TURN STUBSHAFT LEVERS COUNTERCLOCKWISE UNTIL THE FUEL CONTROL LEVERS REST AGAINST THEIR STOPS APPLY 10-50 LB LOAD COUNTERCLOCKWISE TO STUB LEVERS & ADJUST APPROPRIATE STUB SCREW UNTIL CONTACT BETWEEN SCREW & LEVER IS OBTAINED
4- TURN EACH SCREW ONE ADDITIONAL TURN INWARD
5- REPEAT STEP 3 & 4 TURNING STUB LEVERS CLOCKWISE

L-51306
10-75

External Parts (JT3D-1 Douglas,
JT3D-3 Douglas, JT3D-3B Douglas)

Figure 405H (Sheet 2) (CV-3)


VIEW IN DIRECTION EB (7–E)
VIEW CT (8–F)
VIEW IN DIRECTION CS (7–E)
VIEW IN DIRECTION DM (13C)
2018 BOTH ENDS
VIEW DW (8F)
VIEW BT (4D,4E) 3 PLACES
VIEW CU (9–E)
VIEW BE (7D)
VIEW B (11–B)
VIEW CX (9–D)
VIEW CZ (8–C)
VIEW BD (7D)
VIEW FH (8A)
VIEW AH (6D)
PARTIAL FRONT VIEW OF FIRESEAL
VIEW DY (7–C)
SECT DZ (4–C)
VIEW BS (4–D 4–E) 2 PLACES
VIEW CR (7–D)
VIEW EA (4–D)
VIEW P (7–D)
VIEW FG (8–B)
VIEW AX (6A)
VIEW AA (4D)
VIEW AD (5D)
VIEW IN DIRECTION S (7C) FUEL CONTROL LOW PRESSURE TUBE PRIOR TO PN 708241
VIEW BF (8–C)
VIEW IN DIRECTION S
VIEW FE (13–C)
BOTTOM VIEW OF TUBE R (6D & 13D)
VIEW EG (7–D)
SECT THRU COMPANY NAME PLATE
L-51311 10-76



External Parts (JT3D-1 Douglas,
JT3D-3 Douglas, JT3D-3B Douglas)

Figure 405H (Sheet 4) (CV-3)

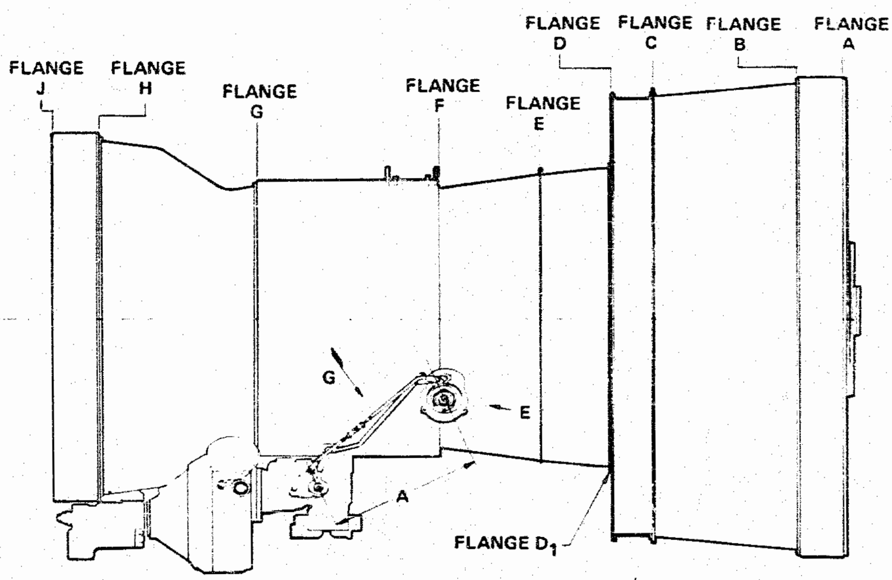
ENGINE - DISMANTLING/ASSEMBLY

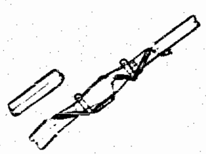
FUEL CONTROL SHUT-OFF
LINKAGE ADJUSTMENT PROCEDURE

1-SET ADJUSTING SCREWS FLUSH WITH STOPS ON STUB SHAFT
2-ADJUST STUB SHAFT LEVER ON ROD SO THAT THE GAPS BETWEEN LEVER ARM & STOPS IN BOTH DIRECTIONS ARE APPROX EQUAL WHEN THE LEVER ARM ON THE FUEL CONTROL RESTS AGAINST ITS STOPS
3-TURN IN ADJUSTING SCREWS UNTIL THEY CONTACT THE STUB SHAFT LEVER ARM
4-TURN SCREWS ONE ADDITIONAL TURN INWARD

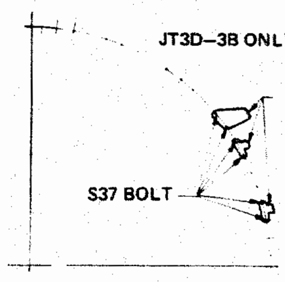
FUEL CONTROL
LINKAGE ADJUSTMENT PROCEDURE

1-MEASURE DISTANCE BETWEEN AXIS OF FUEL CONTROL LEVER & AXIS OF STUBSHAFT LEVER (DIM A ABOVE)
2-ADJUST TURNBUCKLE SO THE DISTANCE BETWEEN END HOLES IS EQUAL WITHIN .005 TO THE DISTANCE MEASURED IN STEP 1
3-TURN STUBSHAFT LEVERS COUNTERCLOCKWISE UNTIL THE FUEL CONTROL LEVERS REST AGAINST THEIR STOPS APPLY 10-50 LB LOAD COUNTERCLOCKWISE TO STUB LEVERS & ADJUST APPROPRIATE STUB SCREW UNTIL CONTACT BETWEEN SCREW & LEVER IS OBTAINED
4-TURN EACH SCREW ONE ADDITIONAL TURN INWARD
5-REPEAT STEP 3&4 TURNING STUB LEVERS CLOCKWISE





VIEW IN DIRECTION G
SHOWING LOCKWIRE PROCEDURE

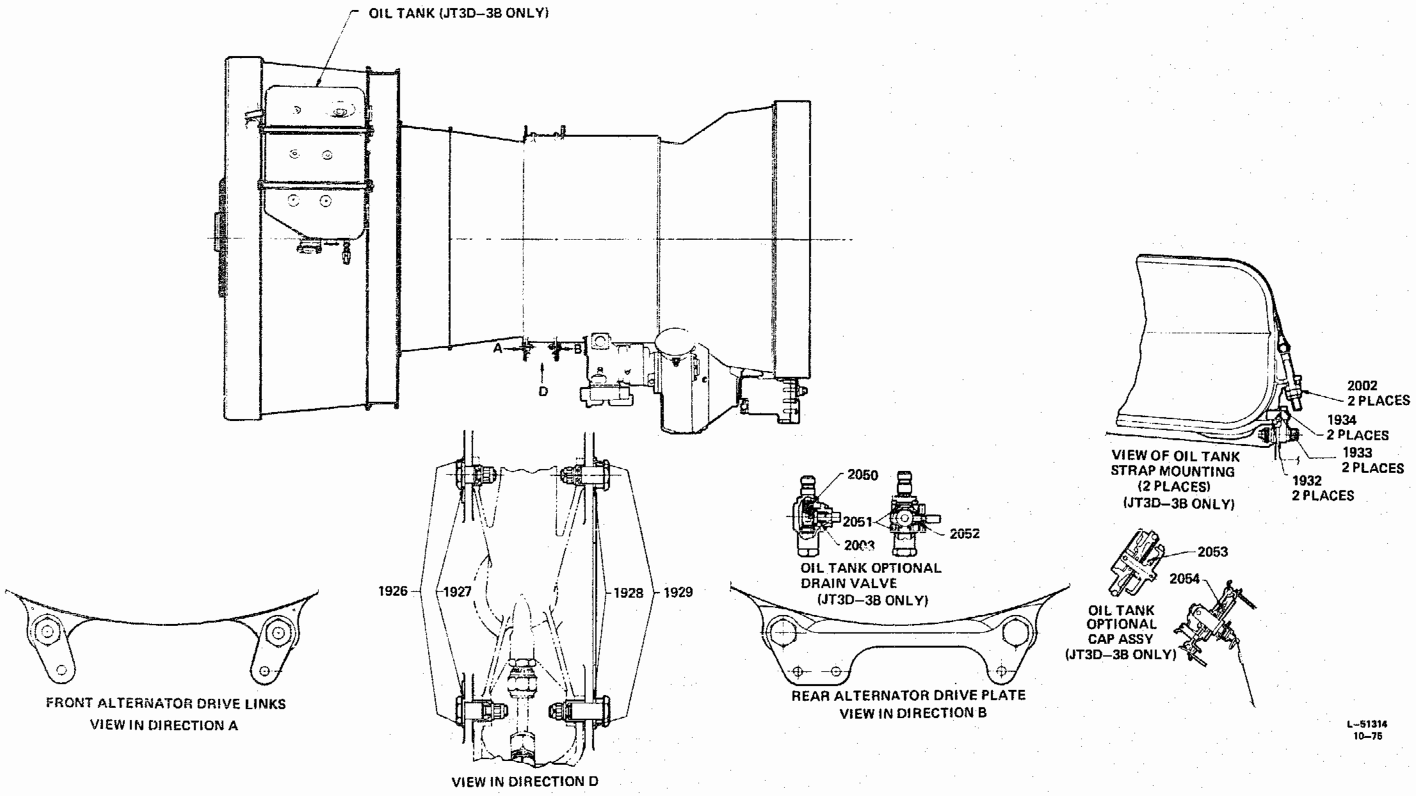


FLANGE B
FRONT VIEW

L-51304
10-75

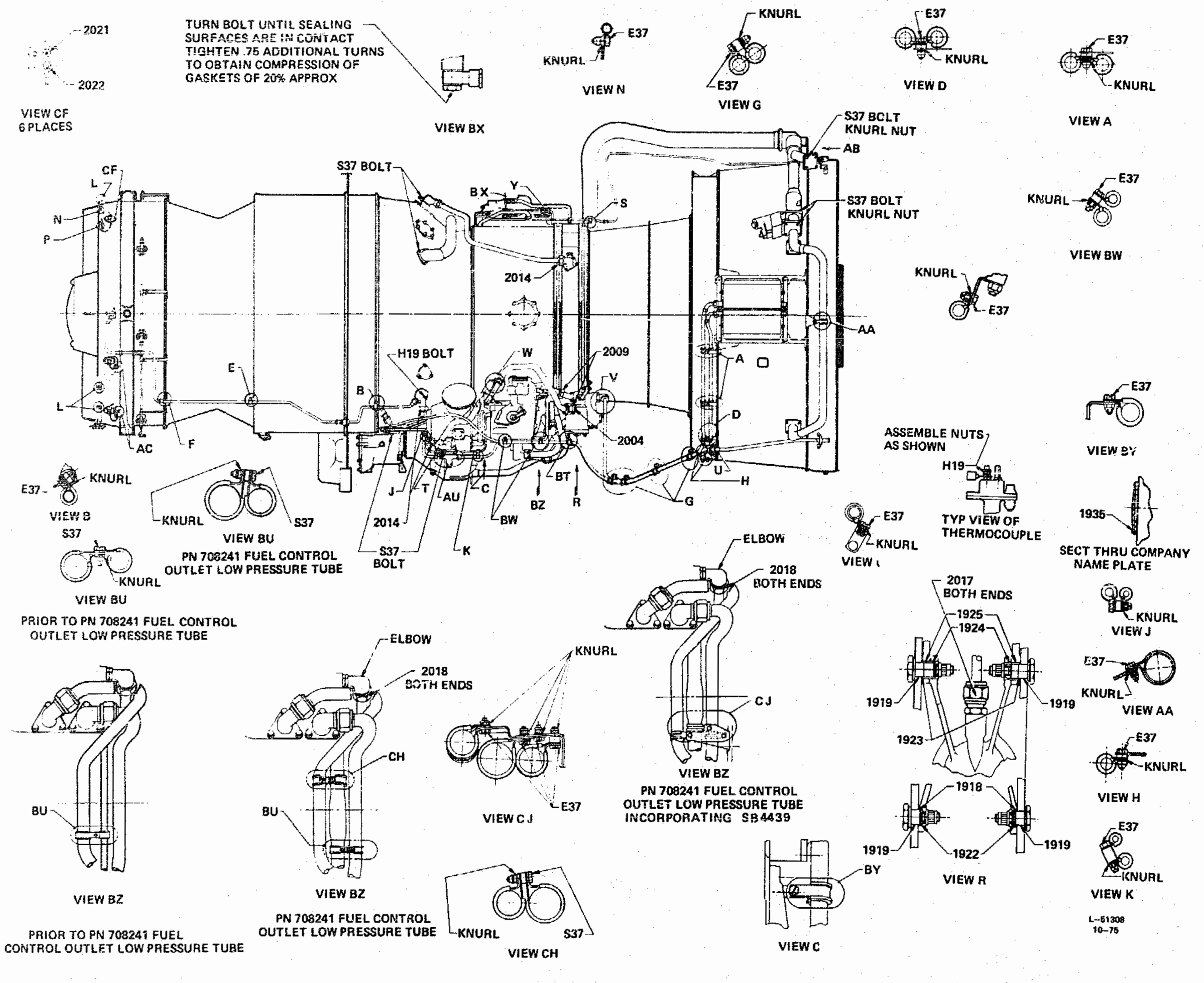
External Parts (JT3D-1 Douglas, JT3D-3 Douglas, JT3D-3B Douglas)

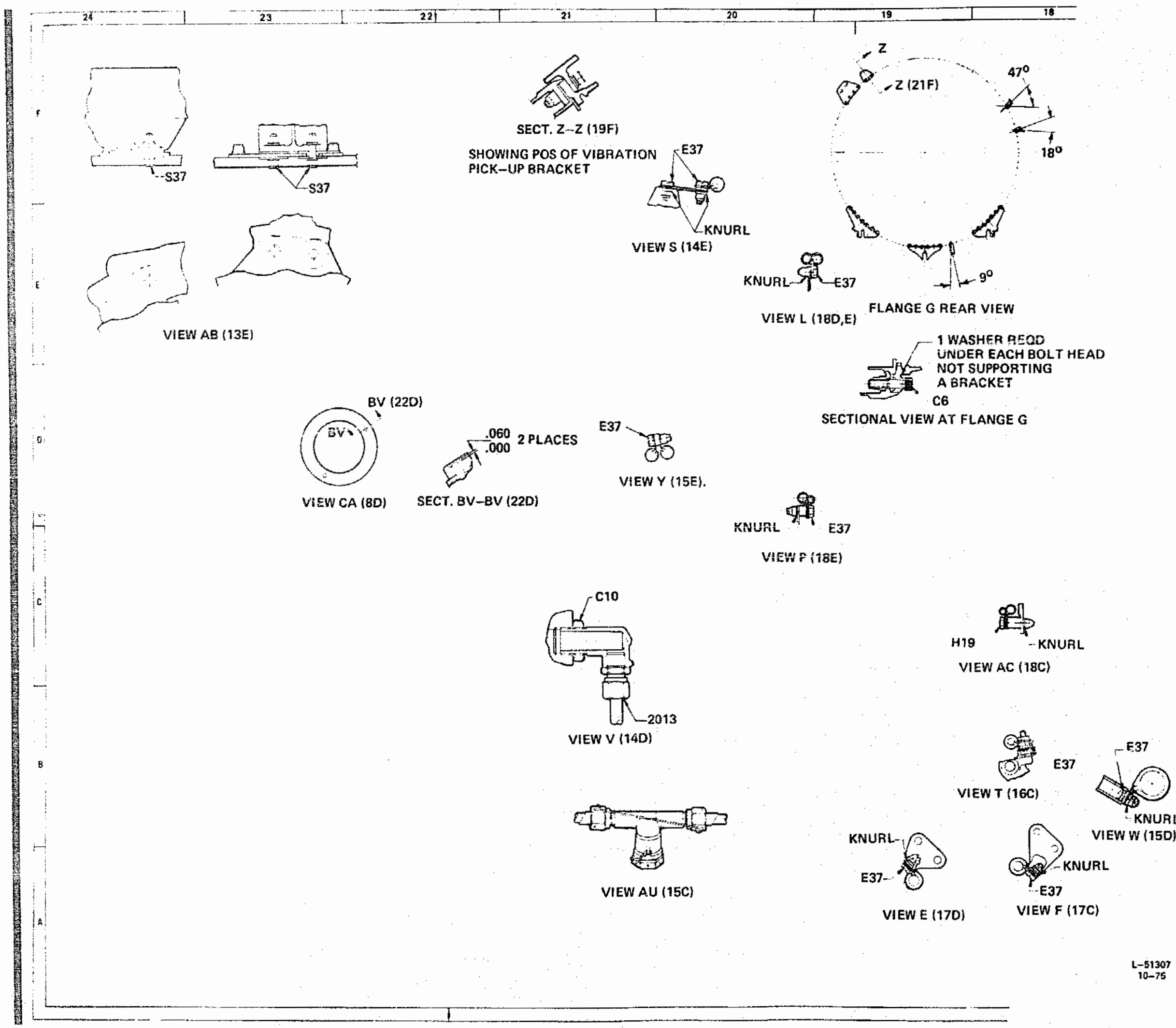
Figure 405H (Sheet 5) (P-1)



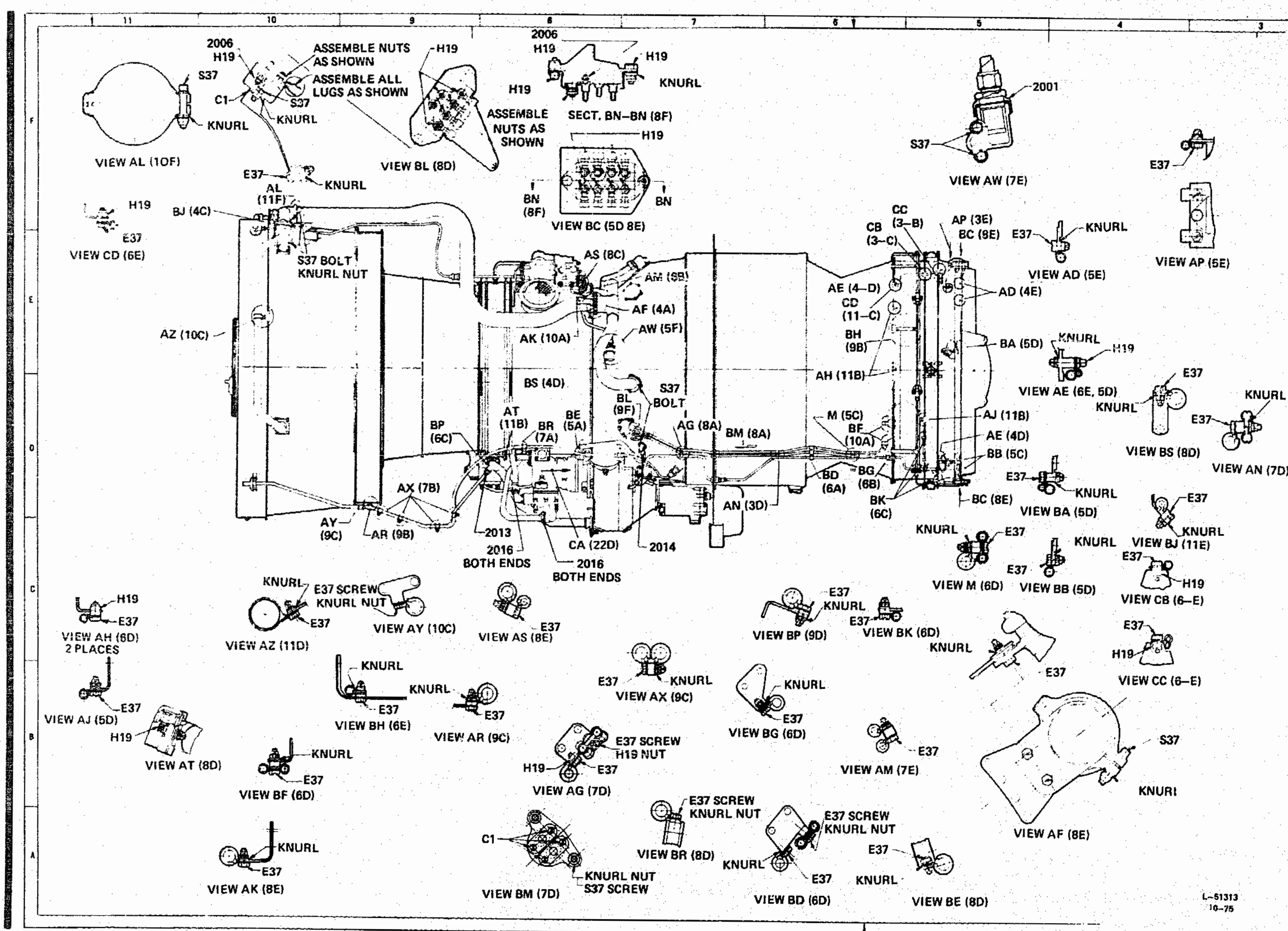
External Parts (JT3D-1 Douglas,
JT3D-3 Douglas, JT3D-3B Douglas)

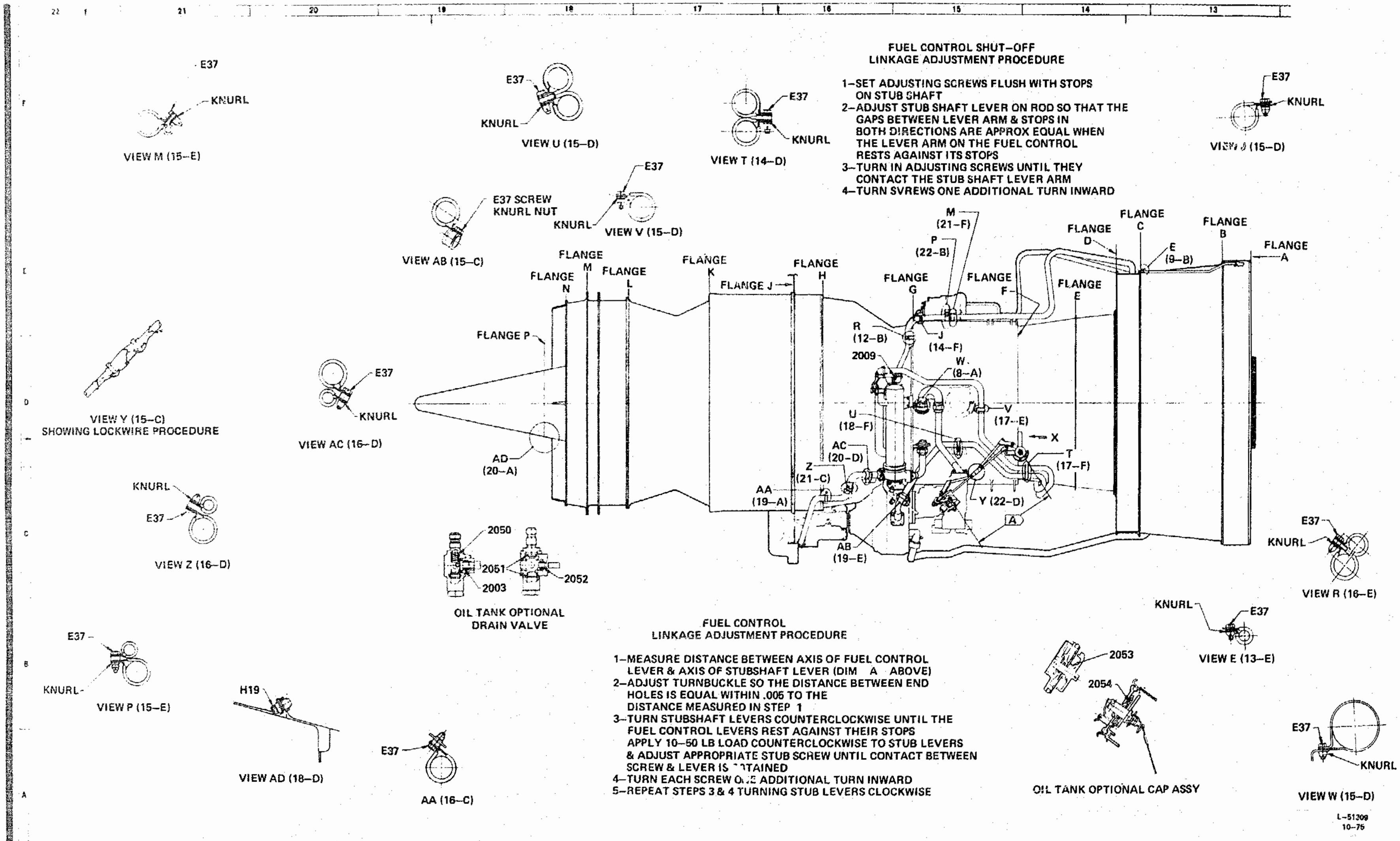
Figure 405H (Sheet 6) (P-1)

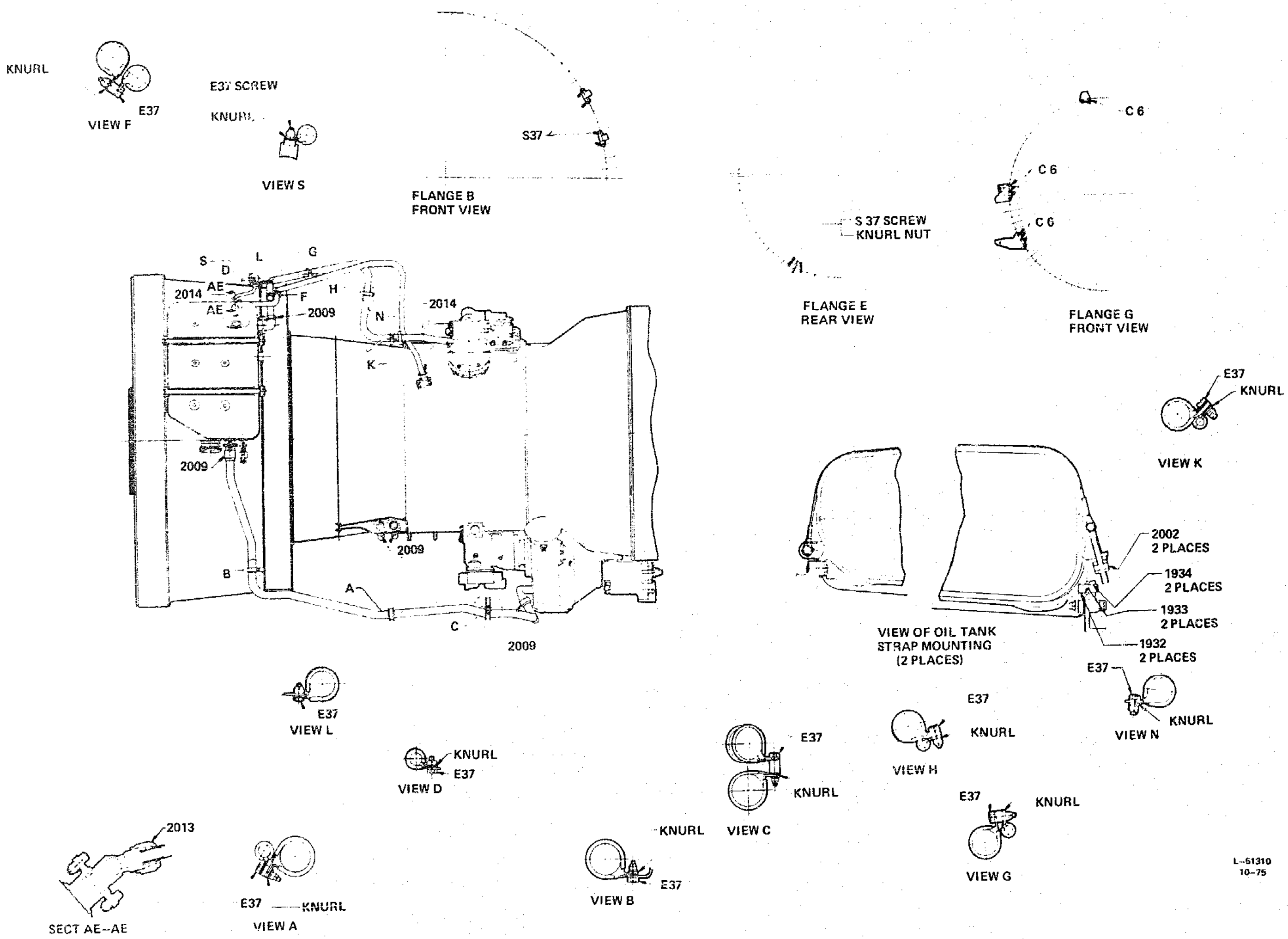

TURN BOLT UNTIL SEALING SURFACES ARE IN CONTACT TIGHTEN .75 ADDITIONAL TURNS TO OBTAIN COMPRESSION OF GASKETS OF 20% APPROX
VIEW CF 6 PLACES
VIEW BX
VIEW N
VIEW G
VIEW D
VIEW A
VIEW BW
S37 BOLT KNURL NUT
H19 BOLT
VIEW B
VIEW BU
PN 708241 FUEL CONTROL OUTLET LOW PRESSURE TUBE
PRIOR TO PN 708241 FUEL CONTROL OUTLET LOW PRESSURE TUBE
ASSEMBLE NUTS AS SHOWN
TYP VIEW OF THERMOCOUPLE
SECT THRU COMPANY NAME PLATE
VIEW BY
VIEW J
VIEW AA
VIEW H
VIEW K
VIEW R
VIEW C
VIEW CH
VIEW CJ
VIEW BZ
PN 708241 FUEL CONTROL OUTLET LOW PRESSURE TUBE INCORPORATING SB4439
PRIOR TO PN 708241 FUEL CONTROL OUTLET LOW PRESSURE TUBE
ELBOW
2018 BOTH ENDS
2017 BOTH ENDS
KNURL
E37
S37
L-51308
10-75

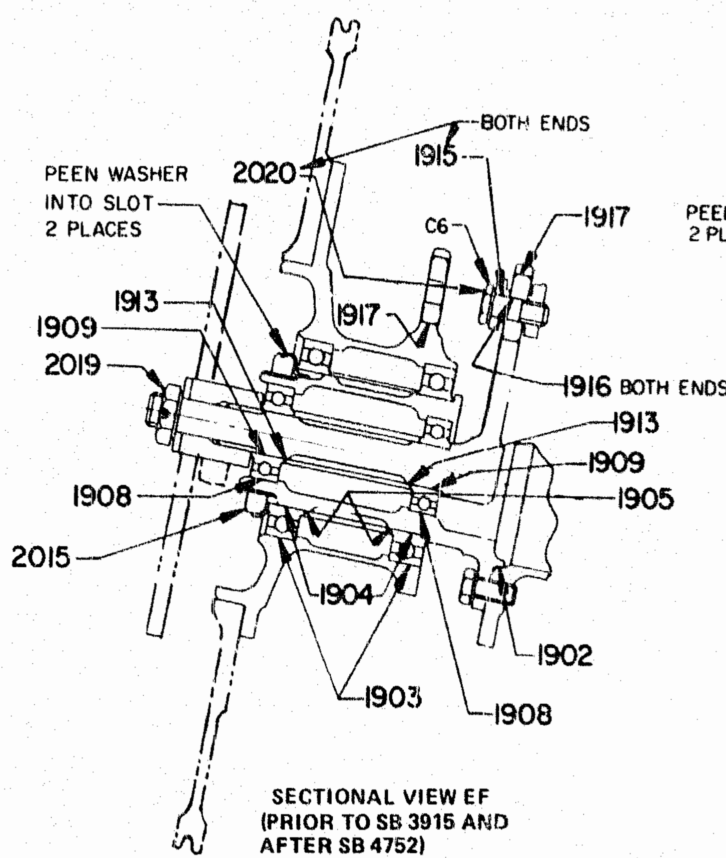

24
23
22
21
20
19
18
S37
S37
VIEW AB (13E)
SECT. Z-Z (19F)
SHOWING POS OF VIBRATION
PICK-UP BRACKET
E37
KNURL
VIEW S (14E)
Z
Z (21F)
47°
18°
9°
KNURL
E37
VIEW L (18D,E)
FLANGE G REAR VIEW
1 WASHER REQD
UNDER EACH BOLT HEAD
NOT SUPPORTING
A BRACKET
C6
SECTIONAL VIEW AT FLANGE G
BV (22D)
BV
VIEW CA (8D)
.060
.000
2 PLACES
SECT. BV-BV (22D)
E37
VIEW Y (15E).
KNURL
E37
VIEW P (18E)
C10
2013
VIEW V (14D)
H19
KNURL
VIEW AC (18C)
E37
VIEW T (16C)
E37
KNURL
VIEW W (15D)
VIEW AU (15C)
KNURL
E37
VIEW E (17D)
KNURL
E37
VIEW F (17C)
L-51307
10-75

ENGINE - DISMANTLING/ASSEMBLY

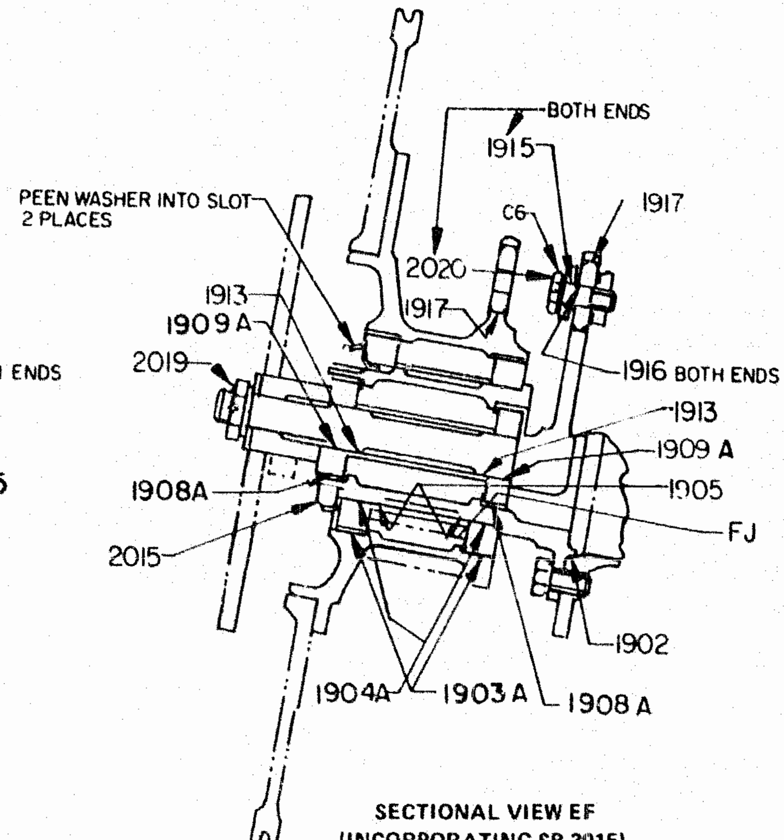



FUEL CONTROL SHUT-OFF
LINKAGE ADJUSTMENT PROCEDURE
1-SET ADJUSTING SCREWS FLUSH WITH STOPS ON STUB SHAFT
2-ADJUST STUB SHAFT LEVER ON ROD SO THAT THE GAPS BETWEEN LEVER ARM & STOPS IN BOTH DIRECTIONS ARE APPROX EQUAL WHEN THE LEVER ARM ON THE FUEL CONTROL RESTS AGAINST ITS STOPS
3-TURN IN ADJUSTING SCREWS UNTIL THEY CONTACT THE STUB SHAFT LEVER ARM
4-TURN SVREWS ONE ADDITIONAL TURN INWARD
FUEL CONTROL
LINKAGE ADJUSTMENT PROCEDURE
1-MEASURE DISTANCE BETWEEN AXIS OF FUEL CONTROL LEVER & AXIS OF STUBSHAFT LEVER (DIM A ABOVE)
2-ADJUST TURNBUCKLE SO THE DISTANCE BETWEEN END HOLES IS EQUAL WITHIN .005 TO THE DISTANCE MEASURED IN STEP 1
3-TURN STUBSHAFT LEVERS COUNTERCLOCKWISE UNTIL THE FUEL CONTROL LEVERS REST AGAINST THEIR STOPS
APPLY 10-50 LB LOAD COUNTERCLOCKWISE TO STUB LEVERS & ADJUST APPROPRIATE STUB SCREW UNTIL CONTACT BETWEEN SCREW & LEVER IS ATAINED
4-TURN EACH SCREW ONE ADDITIONAL TURN INWARD
5-REPEAT STEPS 3 & 4 TURNING STUB LEVERS CLOCKWISE
VIEW M (15-E)
VIEW U (15-D)
VIEW T (14-D)
VIEW J (15-D)
VIEW AB (15-C)
VIEW V (15-D)
E37 SCREW
KNURL NUT
KNURL
E37
FLANGE A
FLANGE B
FLANGE C
FLANGE D
FLANGE E
FLANGE F
FLANGE G
FLANGE H
FLANGE J
FLANGE K
FLANGE L
FLANGE M
FLANGE N
FLANGE P
VIEW Y (15-C)
SHOWING LOCKWIRE PROCEDURE
VIEW AC (16-D)
VIEW Z (16-D)
VIEW R (16-E)
VIEW E (13-E)
VIEW P (15-E)
VIEW AD (18-D)
AA (16-C)
H19
2050
2051
2052
2003
OIL TANK OPTIONAL
DRAIN VALVE
2053
2054
OIL TANK OPTIONAL CAP ASSY
VIEW W (15-D)
L-51309
10-76

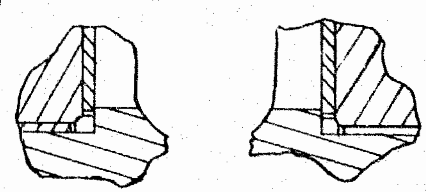

KNURL
E37
VIEW F
E37 SCREW
KNURL
VIEW S
S37
FLANGE B
FRONT VIEW
C6
C6
C6
S 37 SCREW
KNURL NUT
FLANGE E
REAR VIEW
FLANGE G
FRONT VIEW
S
D
L
G
2014
AE
AE
F
H
2009
N
2014
K
2009
2009
B
A
C
2009
E37
KNURL
VIEW K
2002
2 PLACES
1934
2 PLACES
1933
2 PLACES
1932
2 PLACES
VIEW OF OIL TANK
STRAP MOUNTING
(2 PLACES)
E37
KNURL
VIEW N
E37
VIEW L
E37
KNURL
VIEW H
KNURL
E37
VIEW D
E37
KNURL
VIEW C
E37
KNURL
VIEW G
KNURL
2013
E37
VIEW B
SECT AE--AE
E37
KNURL
VIEW A
L-51310
10-75



SECTIONAL VIEW EF
(PRIOR TO SB 3915 AND
AFTER SB 4752)



SECTIONAL VIEW EF
(INCORPORATING SB 3915)



VIEW FJ
(BEARINGS MUST BE INSTALLED
AS SHOWN—2 PLACES)

L—44456
9—81

14D. Installation And Handling Of Ball and Roller Bearings

A. Procedure

(1) Wear a clean pair of gloves, made of an approved lint free material, when handling bearings.

(2) When assembling inner races of bearings on their mating shafts, it will be necessary to expand inner race by using controlled heating. The inner race of demountable bearings and complete bearing assembly of nondemountable bearings may be raised to required temperature by immersion in a controlled hot oil bath. Shafts and bearing races must be checked for size and trueness before heating in order to avoid abnormal fits. Hot oil tanks used for expansion heating must be kept closed when not in use to minimize contamination of oil by airborne dirt and abrasives.

(3) Never allow bearings to rest on bottom of a hot oil tank since they may become contaminated from settlings and their temperature will be much higher than indicated oil temperature. A heavy screen or series of rods extending three or more inches above tank bottom will keep bearings surrounded by oil at a uniform temperature and will allow any dirt to settle at bottom of tank. Use engine oil thermostatically controlled at temperatures not exceeding 250°F (121°C). Change oil and clean tank periodically as necessitated by amount of use.

14E. Installation Of Cup Type Key Washers

A. Procedure

See Figure 405J.

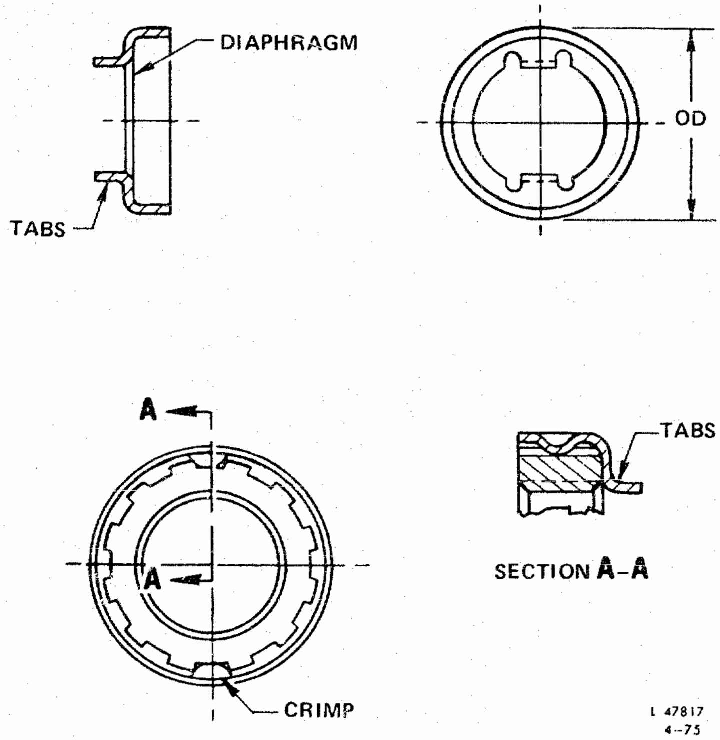
(1) General. After nut has been correctly seated and tightened to required torque, cup type key washer shall be indented as specified. Where number of rounded slots in nut or bolt is less than required indentations listed, crimping must be accomplished at each available location. Portion of tool that forms indentations shall be spherically shaped and have spherical radius of not less than 0.050 inch.

(2) Position Control. To preclude shearing of tabs, position of cup washer shall be indicated by marking cup washer and adjacent surface so that any rotation of cup washer can be detected when torquing nut.

(3) Acceptance Standards

(a) New cut type key washer was used.

CAUTION: CUP TYPE KEY WASHERS THAT ARE LOOSE ENOUGH TO SHAKE OR RATTLE ARE NOT ACCEPTABLE.



Indentations Required

Thread Size (Inches)	Number	Spacing
0.000 - 1.500	2	$180^\circ \pm 30^\circ$ Apart
1.500 - 2.500	4	$90^\circ \pm 30^\circ$ Apart
2.500 - 4.000	6	$60^\circ \pm 15^\circ$ Apart
Over 4.000	8	$45^\circ \pm 15^\circ$ Apart

Typical Crimping Of Internal And External Cup Type Key Washers

Figure 405J

(b) Indentations were formed as shown. A properly secured cup washer will normally be tight, but in instances where there is not axial pinch on the diaphragm portion of washer, washer may be moved by hand through limits of tab clearance.

(c) Indentations in any one washer shall be approximately same shape and size, and shall not be broken, cracked or torn.

(d) Indentations in cup washer shall have been formed into rounded slots in nut when nut is provided with such slots.

(e) Cup washer has not moved during assembly.

14F. Installation Of Tab And Elliptical Type Key Washers

A. Installation Of Tab Type Key Washers

See Figure 405K.

(1) Key washers must be used only one time.

(2) Key washer shall be positioned such that unbent keys are as far as possible from axis of part to be locked. Prebent key, Key B, shall be tight to overhanging surface or brace against side of hole as shown to prevent possible movement of part being locked.

(3) All unbent keys on key washer are to be bent as safeguard against reuse.

(4) To preclude shearing of internal tabs, position of key washer shall be indicated by marking key washer and adjacent nonrotating surface so that any rotation of key washer can be detected when tightening nut.

B. Installation of Elliptical Key Washers

See Figure 405L.

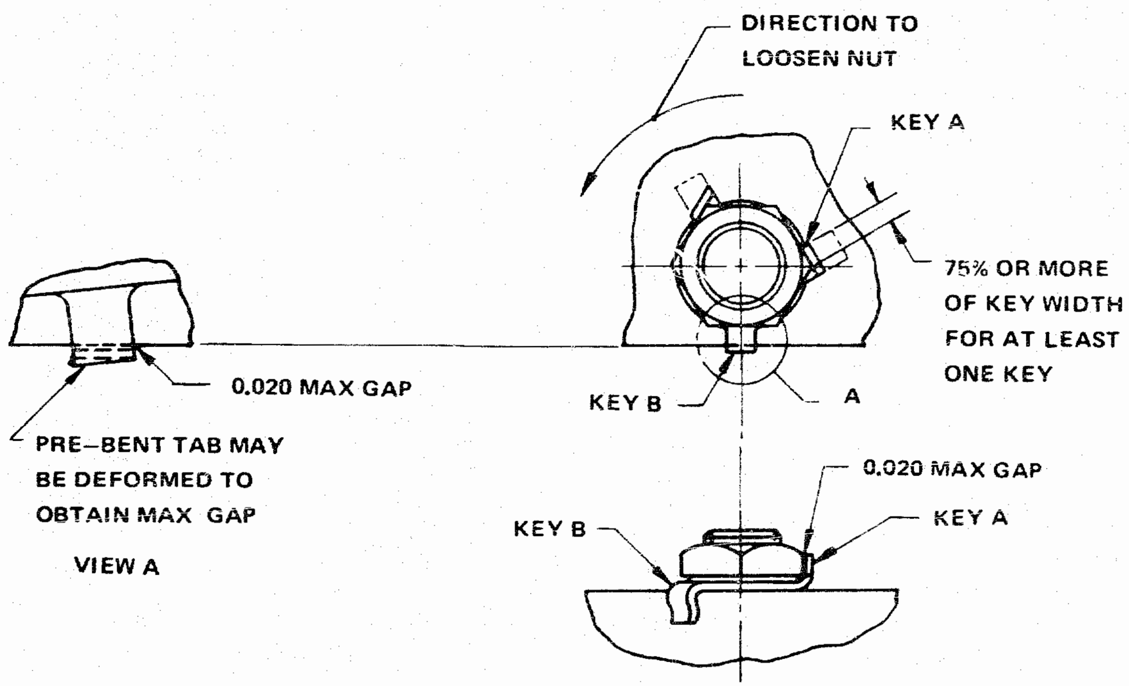
(1) Install elliptical type key washers as shown in referenced figure.

14G. Lockwiring

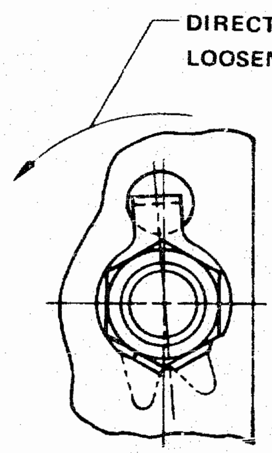
A. Procedure

See Figures 405M and 405N.

(1) Check fasteners to be lockwired to make sure that they have been correctly torqued and that lockwire holes are properly positioned in relation to each other. Never overtorque or loosen fasteners to obtain proper alignment of lockwire holes. Select another fastener, if necessary, to obtain proper alignment of lockwire holes with specified torque limits.



PRE–BENT KEY OVERHANGING ADJACENT SURFACE

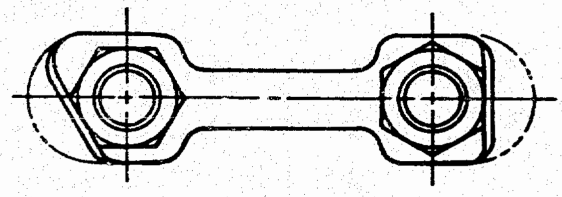


PRE–BENT KEY ANCHORED IN ADJACENT HOLE

L 47860
4 75

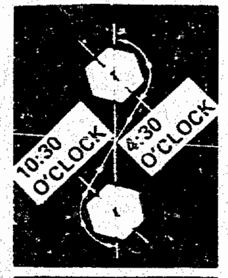
Installation Of Tab Type Key Washer

Figure 405K

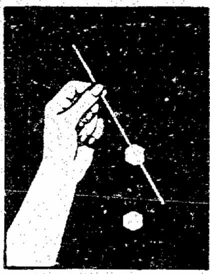


NOTE: Key washer must be used only one time. Installation of this type of key washer shall be accomplished by bending washer up across one whole face of hexagon as shown with a 0.020 inch maximum gap between flat of nut and washer.

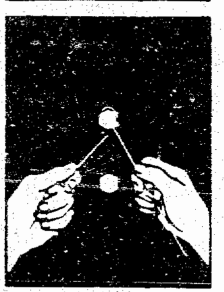
Installation of Elliptical Type Key Washer
Figure 405L



POSITION THE HOLES.

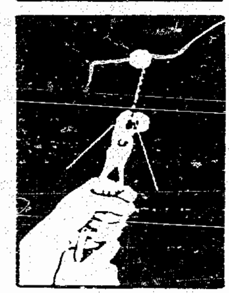


INSERT PROPER GAGE WIRE. TO DETERMINE THE PROPER WIRE TO BE USED IN CONJUNCTION WITH A PARTICULAR TIGHTENING OPERATION REFER TO THE CORRESPONDINGLY DESIGNATED ENGINE PARTS CATALOG OR ILLUSTRATED PARTS BREAKDOWN. LOCKWIRE WHICH IS SPECIALLY TREATED FOR 1800°F (982°C) APPLICATIONS HAS A DARK GRAY TO BLACK COLOR.

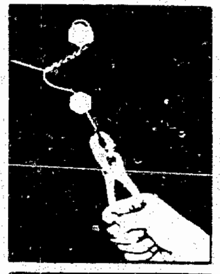


GRASP UPPER END OF THE WIRE AND BEND IT AROUND THE HEAD OF THE BOLT, THEN UNDER THE OTHER END OF THE WIRE. BE SURE WIRE IS TIGHT AROUND HEAD.

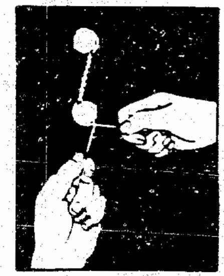
TWIST WIRE UNTIL WIRE IS JUST SHORT OF HOLE IN THE SECOND BOLT.



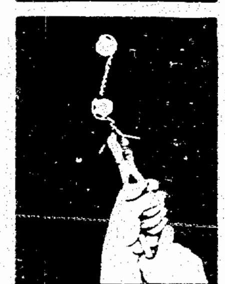
KEEPING WIRE UNDER TENSION, TWIST IN A CLOCKWISE DIRECTION UNTIL THE WIRE IS TIGHT. WHEN TIGHTENED THE WIRE SHALL HAVE APPROXIMATELY 7–10 TWISTS PER INCH.



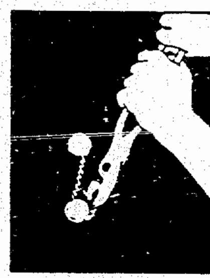
INSERT THE UPPERMOST WIRE, WHICH POINTS TOWARDS THE SECOND BOLT, THROUGH THE HOLE WHICH LIES BETWEEN THE NINE AND TWELVE O'CLOCK POSITIONS. GRASP THE END OF THE WIRE WITH A PAIR OF PLIERS AND PULL THE WIRE TIGHT.



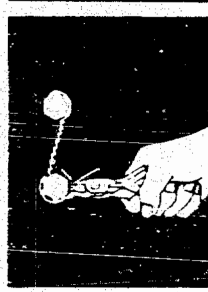
BRING THE FREE END OF THE WIRE AROUND THE BOLTHEAD IN A COUNTERCLOCKWISE DIRECTION AND UNDER THE END PROTRUDING FROM THE BOLT HOLE. TWIST THE WIRE IN A COUNTERCLOCKWISE DIRECTION.



GRASP THE WIRE BEYOND THE TWISTED PORTION AND TWIST THE WIRE ENDS COUNTERCLOCKWISE UNTIL TIGHT.



DURING THE FINAL TWISTING MOTION OF THE PLIERS, BEND THE WIRE DOWN AND UNDER THE HEAD OF THE BOLT.



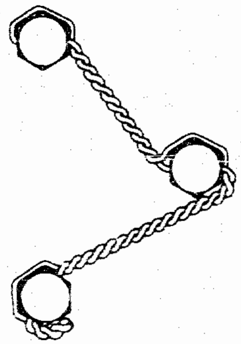
CUT OFF EXCESS WIRE WITH DIAGONAL CUTTERS.

L-5254
11–75

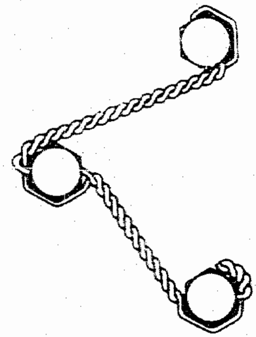
Lockwiring Technique

Figure 405M

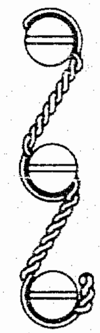
EXAMPLE 1



EXAMPLE 2



EXAMPLE 3

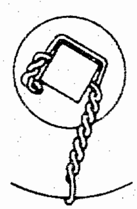


EXAMPLE 4

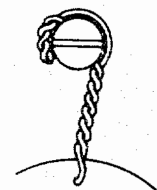
Examples 1, 2, 3, and 4 apply to all types of bolts, fillister head screws, square head plugs, and other similar parts which are wired so that the loosening tendency of either part is counteracted by tightening of the other part. The direction of twist — from the second to the third unit is counterclockwise to keep the loop in position against the head of the bolt. The wire entering the hole in the third unit will be the lower wire and by making a counterclockwise twist after it leaves the hole, the loop will be secured in place around the head of that bolt.

EXAMPLE 5

EXAMPLE 6

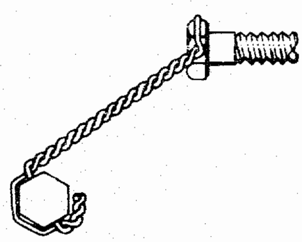


EXAMPLE 7



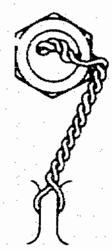
EXAMPLE 8

Examples 5, 6, 7 & 8 show methods for wiring various standard items. Note: Wire may be wrapped over the unit rather than around it when wiring castellated nuts or on other items when there is a clearance problem.



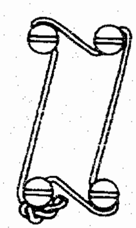
EXAMPLE 9

Example 9 shows the method for wiring bolts in different planes. Note that wire should always be applied so that tension is in the tightening direction.



EXAMPLE 10

Hollow head plugs shall be wired as shown with the tab bent inside the hole to avoid snags and possible injury to personnel working on the engine.

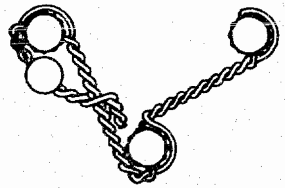


EXAMPLE 11

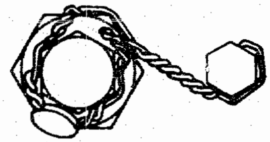
Correct application of single wire to closely spaced multiple group.

L-5246
2-73

Examples Of Proper Lockwiring
Figure 405N (Sheet 1)



EXAMPLE 12

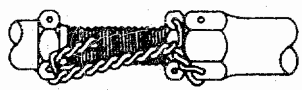


EXAMPLE 13

Examples 12 & 13 show methods for attaching lead seal to protect critical adjustments.

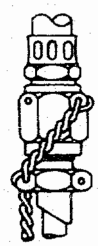
EXAMPLE 14

Example 14 shows bolt wired to a right angle bracket with the wire wrapped around the bracket.



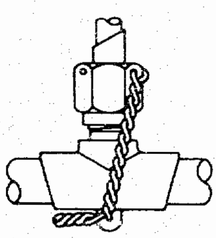
EXAMPLE 15

Example 15 shows correct method for wiring adjustable connecting rod.

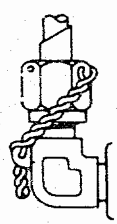


EXAMPLE 16

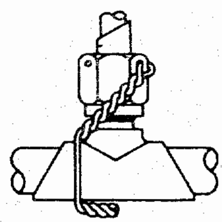
Example 16 shows correct method for wiring the coupling nut on flexible line to the straight connector brazed on rigid tube.



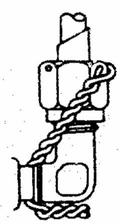
EXAMPLE 17



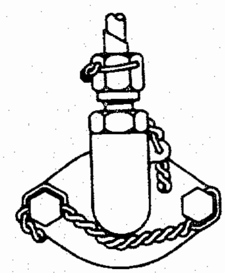
EXAMPLE 18



EXAMPLE 19



EXAMPLE 20



EXAMPLE 21

Fittings incorporating wire lugs shall be wired as shown in Examples 17 & 18. Where no lockwire lug is provided, wire should be applied as shown in Examples 19 & 20 with caution being exerted to ensure that wire is wrapped tightly around the fitting.

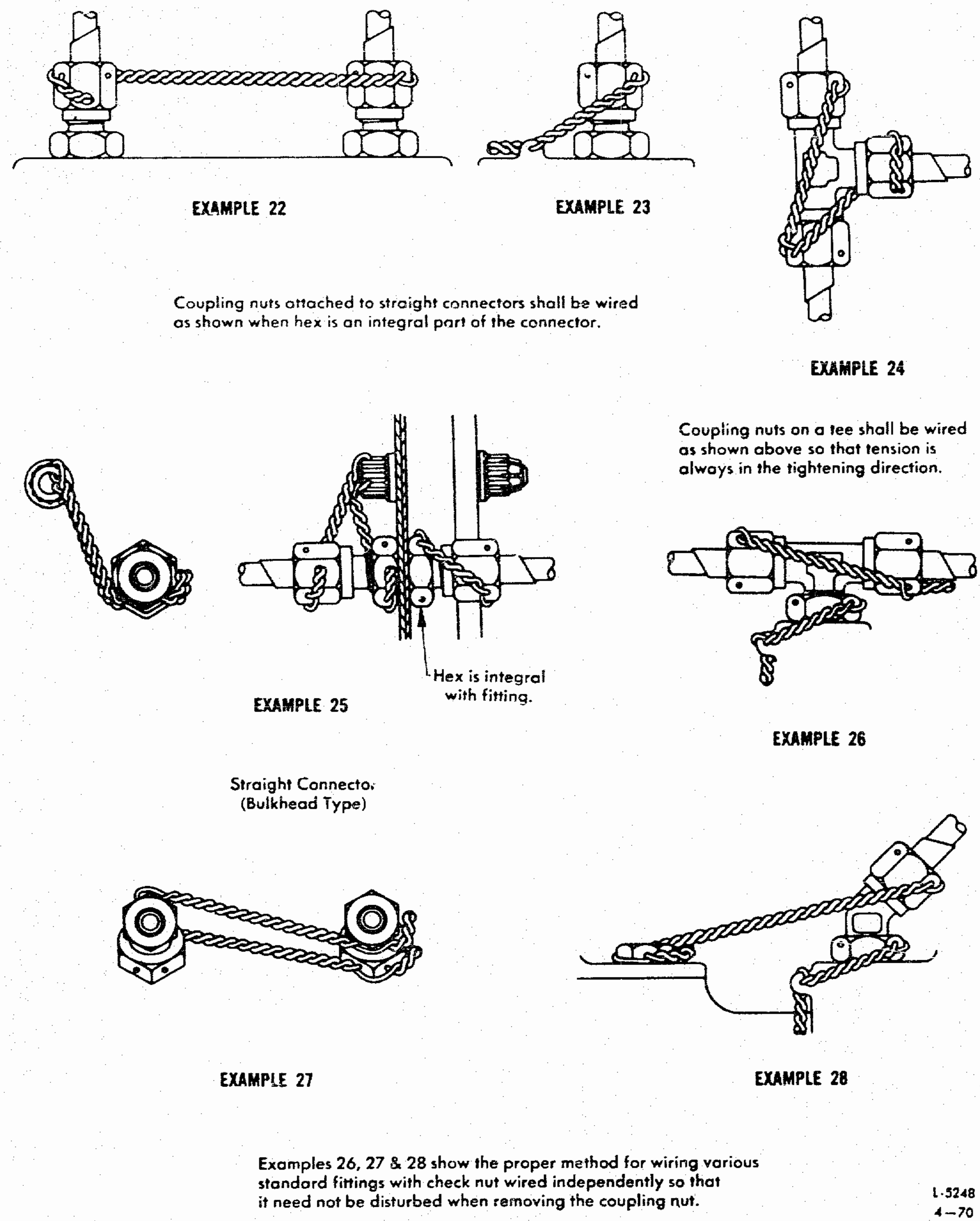
Small size coupling nuts shall be wired by wrapping the wire around the nut and inserting it through the holes as shown.

L-5247

Examples Of Proper Lockwiring

Figure 405N (Sheet 2)

ENGINE - DISMANTLING/ASSEMBLY



Examples Of Proper Lockwiring
Figure 405N (Sheet 3)

(2) Install lockwire in a manner that tends to tighten and keep a part locked in place, counteracting natural tendency of part to loosen. Lockwire shall not have any additional tension imposed upon it other than original tension to prevent loosening. Where slack is required between tension points, it shall be specified. Install lockwire so that, after installation, neither wire nor its adjacent parts will be subject to wear or excessive load.

(3) To prevent mutilations on twisted section of wire when using pliers, grasp wire at ends or at a point that will not be twisted. Lockwire must not be nicked, kinked, or multilated. Never twist excess wire ends off with pliers.

(4) Lockwire must be taut when installed to prevent failure due to rubbing or vibration. Lockwire shall have approximately 7 to 10 twists per inch; one twist is defined as being produced by twisting wires through an arc of 180 degrees and is equivalent to one-half a complete turn. Do not overtighten.

(5) When trimming ends, leave at least three complete turns after loop, exercising due care to prevent wire ends from falling into engine.

(6) Ends of lockwire must be bent toward part to avoid sharp or projecting ends which might present a safety hazard.

14H. Cotter Pins

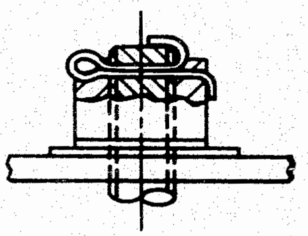
A. General. Cotter pins are not reusable. New cotter pins must be used for each application.

B. Locking Nuts With Cotter Pins

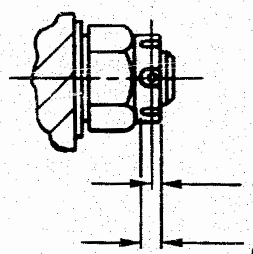
See Figure 4050.

(1) Before installing cotter pin, tighten nut to low side of required torque range, unless otherwise specified, then continue tightening until slot aligns with hole in bolt. If slot in nut does not line up with hole before maximum allowable torque is reached, back off nut, then retighten. If slot still does not line up, select new nut and repeat assembly procedure.

(2) While preferred installation would locate centerline of hole in bolt midway into nut slot, any installation wherein more than 50 percent of cotter pin diameter is located below nut castellation is acceptable. In event 50 percent or more of cotter pin diameter is located above nut castellation, new nut must be selected and installed.



PREFERRED INSTALLATION



LOCATION OF LOCKING
HOLE IN SLOT OF NUT

L-28805

Locking Nuts With Cotter Pins

Figure 4050

(3) Install each cotter pin with head seated firmly in slot of nut with axis of eye at right angles to bolt. Bend prongs so that head and upper prong are firmly seated against bolt, and lower prong is firmly seated against corresponding nut flat. Upper prong may be cut off even with top of bolt to provide necessary clearance. Lower prong may also be cut off to provide necessary clearance and/or a snug fit against corresponding nut flat.

C. Retaining Pins And Rod Ends With Cotter Pins

See Figure 405P.

(1) Install cotter pin with axis of eye parallel to shank of clevis pin or rod end. Bend prongs around shank of pin or rod end. Prongs may be cut to obtain normal end position.

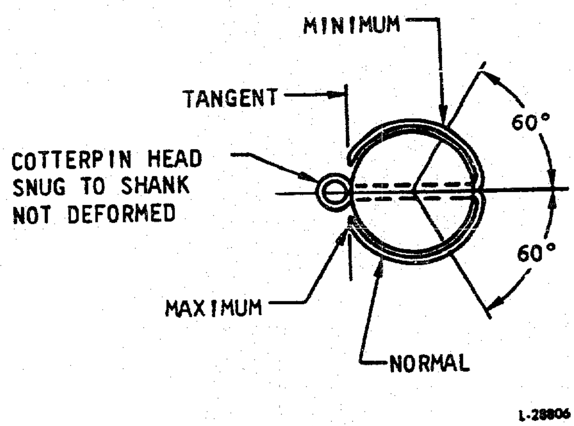
14I. Installation of Retaining Rings

A. General. Retaining rings must be installed using approved retaining ring pliers. Internal type rings must not be compressed beyond point where ends of rings meet. External type rings must be expanded only enough to allow installation without becoming bent. After installation, ensure that each retaining ring is completely seated, without looseness or distortion, in its groove. Distorted or loose retaining rings must be replaced.

B. Plain Retaining Rings

(1) Plain retaining rings may contain slightly rounded edges on one side and sharp edges on opposite side. Slight rounding, caused by stamping die, is not a bevel and ring must not be classified as a beveled ring.

(2) Plain retaining rings must be installed only in square sided grooves. When one side of a plain ring has visibly sharper corners, this side must be installed away from detail part(s) being retained, so that sharp-edged side thrusts against groove.



Installing Cotter Pin On End Of Retaining Pin/Rod
Figure 405P

ENGINE - DISMANTLING/ASSEMBLY

14J. Guidelines For Reuse Of Damaged Engines And Engine Parts

A. General

(1) The following guidelines are provided to assist owners, operators and maintenance facilities in the disposition of engines and engine parts involved in Abnormal Operational Circumstances. Abnormal Operational Circumstances are defined as accidents or other events which fall outside of the operating envelope for the engine, aircraft and/or the engine/aircraft combination as originally certified and where inspection, refurbishment, and repair data are not addressed by FAA approved publications, i.e., engine manuals, service bulletins, etc. The data contained in these FAA approved publications normally address engine and engine parts which experience wear, deterioration, or damage through exposure to the normal day-to-day operating environment. The guidelines apply to the following engine associated Abnormal Operational Circumstances:

(a) Engine and engine parts unacceptable for continued aircraft usage. See Paragraph B.

(b) Engines and engine parts potentially acceptable for continued aircraft usage. See Paragraph C.

(2) For Abnormal Operational Circumstances not addressed by these guidelines, Pratt & Whitney considers engines and engine parts unacceptable for continued aircraft usage unless reviewed and approved on a case-by-case basis.

(3) The guidelines are based upon Pratt & Whitney's general experience in this area and therefore are to be used as general guidelines. In any particular incident, however, more complete information or inspection results may require alternate action. The engine or engine part owner should not rely upon the information in these guidelines without a thorough understanding of the damage to the engine or engine parts and its effect on engine operation. <u>It should be understood that the following are only guidelines and that any and all responsibility for returning any engine or engine part to service remains with the engine or part owner</u>.

(4) The following are definitions of technical terms used in these guidelines:

(a) Definitions from ATA World Airlines Technical Operations Glossary (WATOG).

1 <u>Accident</u>: An occurrence associated with the operations of an aircraft which takes place between the time any person boards the aircraft with the intention of flight, until such time as all such persons have disembarked, in which:

a Any person suffers death or serious injury as a result of being in or upon the aircraft, or by direct contact with the aircraft or anything attached thereto; or

b The aircraft receives substantial damage; or

c Any damage is caused to the property of a third party.

2 <u>Damage, accidental</u>: Physical deterioration of an item caused by contact or impact with an object or influence which is not a part of the aircraft, or by improper manufacturing or maintenance practices.

(b) Non-WATOG definitions used in the guidelines

1 <u>Engine</u>: Engines manufactured by Pratt & Whitney Division of United Technologies Corporation.

2 <u>Engine parts</u>: Parts sold by Pratt & Whitney and delivered as original equipment in an engine installed on an aircraft or in a spare engine or parts sold by Pratt & Whitney as new spare parts in support of an engine. Engine parts include Pratt & Whitney authorized vendor supplied accessories and components.

3 <u>Abnormal operational circumstances</u>: Accidents or other events which fall outside the operating envelope for the engine, aircraft, and/or the engine aircraft combination as originally certified and where inspection, refurbishment, and repair data are not addressed by FAA approved publications, i.e., engine manuals, service bulletins, etc.

4 Partially damaged engines which will not rotate freely as a result of superficial damage to cases, etc.

5 Engines subjected to partial or full immersion in fresh or salt water for a brief period of time.

(b) Acceptance criteria for Paragraph C.(1)(a) engines or engine parts:

1 Engines and engine parts involved in accidents described in Paragraphs C.(1)(a)1 and C.(1)(a)2 can be considered "not involved" in an Abnormal Operational Circumstance.

2 Engines and engine parts involved in accidents described in Paragraph C.(1)(a)3, C.(1)(a)4, and C.(1)(a)5 should be 100 percent disassembled and inspected.

NOTE: Owners who are unable to perform the necessary tests or who are in doubt whether to accept or reject a part should contact Pratt & Whitney for assistance.

D. Serious Operational Events

(1) Pratt & Whitney considers engines and engine parts involved in the following types of serious operational events as potentially acceptable for continued aircraft usage provided the criteria defined are observed.

(a) Single fan blade fractures outboard of mid span shroud.

NOTE: A single fan blade fracture occurring outboard of the mid span shroud can cause varying degrees of engine damage. Refer to Inspection/Check for bird or object ingestion inspections and damage limits. In general, the following inspection guidelines can be applied to events where a single blade has fractured outboard of the mid span shroud.

1 Check for evidence of core ingestion.

2 Inspect fan blade shrouds for evidence of shingling.

3 Inspect fan rubstrip for damage beyond limits.

4 Check fan exit guide vanes for damage.

5 Inspect engine externals for broken or cracked brackets and case flanges.

6 Borescope inspect compressor gaspath for excessive blade tip rub and blade-to-vane clash.

(b) Single blade fracture inboard of mid span shroud or multiple fan blade fractures.

NOTE: A fan blade fracture inboard of the mid span shroud or multiple fractures generate a significant amount of rotor vibration. More extensive inspections with disassembly of the N1 rotor modules is required as a minimum. Further disassembly is required as inspection findings dictate.

(c) Engines experiencing sudden stoppage.

1 Engines experiencing sudden stoppage usually as a result of significant ingestion or distress. In every instance of sudden stoppage a complete engine disassembly and 100 percent engine part inspection should be accomplished.

(d) Engines involved in an operational fire (burnthrough, bearing compartment, etc.).

1 Engines involved in an operational fire should be completely disassembled and all engine parts inspected.

2 If extinguishing agents have been applied to the engine, gaspath cleaning is to be accomplished as quickly as practical to prevent corrosion.

E. "Impacted" And "Dropped" Engines

(1) The damage or circumstances which can result in an "Impacted" engine include impact with the ground, a collision with a service vehicle, etc. An engine dragged on the ground or against another object is considered an impacted engine. "Dropped" engines refer to engines which are dropped entirely or on either end. Inspection requirements for impacted and dropped engines are similar and progressive in scope; that is, proceeding with further disassembly is dependent on the degree of damage found at each level of inspection.

ENGINE - DISMANTLING/ASSEMBLY

R (a) For engine mounted on aircraft where pylon or nacelle damage has occurred, inspect engine mount flanges, cases, external components and plumbing, and gearbox housing and mounts. If the impact was such that debris may have entered the engine inlet, inspect engine for ingestion, and check bleed system filters and valves for debris.

R 1 If no damage is noted, no further action is required.

R 2 If damage is noted to external components and plumbing, replace damaged items.

R 3 If damage is noted to mount flanges, gearbox or gearbox mounts or cases, remove engine.

R 4 Monitor chip detectors and oil filter on a more frequent basis during the initial return of the engine to service.

R (b) For dropped engines removal and disassembly are required.

R F. Tailpipe Fires

R (1) In general tailpipe fires of short duration and extinguished by "motoring" the engine will probably have little detrimental effect on exhaust area engine parts. (Refer to PWA Operating Instructions 190).

R (a) Inspect exhaust area for signs of scorching. Any parts which exhibit scorching including fan duct acoustic liners if so equipped, should be replaced.

R (2) Engines which experience a more persistent tailpipe fire or when starting overtemperature limits are exceeded during a tailpipe fire present a greater potential for thermal stress. Engine removal is required.

G. Engine Contamination - Fire Extinguishing Agents

NOTE: The following general information is provided to assist operators in determining appropriate actions for engines subjected to fire extinguishing agents. This information is applicable in instances where fires have been confined to burner and turbine gaspath areas, and over-temperature limits have not been exceeded.

(1) There has been considerable effort expended to determine the effects of commonly used fire extinguishing agents (sodium bicarbonate, potassium bicarbonate and bromotrifluoreomethane (CBrF3) on turbine engine parts.

(2) The major concern with introducing dry powder chemicals into the engine is corrosion during subsequent engine operation. This material can be extremely detrimental to hot section parts, as exposure to the engine operating environment converts the bicarbonate compounds to carbonates, which then form a highly corrosive liquid flux.

(3) Test results reveal stainless steels, nickel base alloys (coated or uncoated), and cobalt base alloys, show a high degree of susceptibility to chemical corrosion, even at temperatures considerably below the engine operating range of approximately 1200°F (649°C). Titanium, aluminum, magnesium, cadmium plate and nickel-cadmium plated low alloy steels evidenced no corrosion from bicarbonate compounds at engine operating temperatures.

(4) Regarding the use of CBrF3, used primarily as an inflight fire extinguishing agent, one manufacturer of the compound stated that the products of decomposition will include certain acids which may have a slight corrosive effect on metals when exposed to high temperatures. PWA 45, PWA 47, PWA 73, PWA 273, and PWA 275 coatings degrade completely from CBrF3 contact at 1800°F for short periods of time.

ENGINE - DISMANTLING/ASSEMBLY

R (5) Although no specific testing has been done relative to the effects these agents have on the oil system, the oil system should also be considered because agents could enter the oil system through labyrinth seals.

R (6) Cleaning methods for engine subjected to fire extinguishing agents should be carefully adhered to in order to minimize damage.

15. Removal/Installation of the Engine From/In the Transportation Stand

See Figure 406.

A. Removal

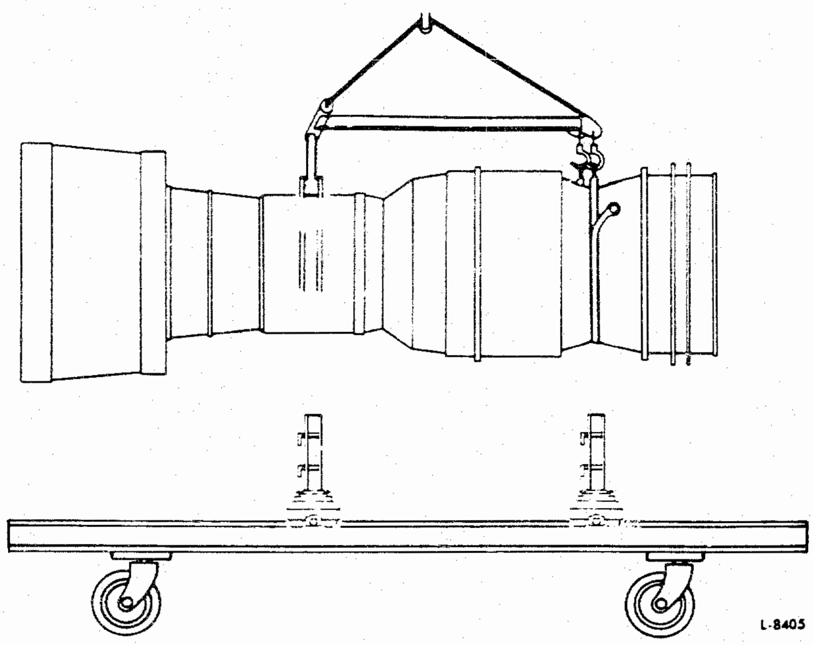
(1) Attach the PWA 16220 Adapter to 12 o'clock holes on intermediate case.

(2) If not installed, pass PWA 8663 Saddle under and around turbine nozzle case so that saddle contacts necked-down surface of case.

(3) Secure PWA 10859 Lifting Sling to lifting adapter on compressor intermediate case and saddle on turbine nozzle case. Attach sling to chain hoist.

NOTE: Compression bar on sling must be adjusted to agree with engine being lifted.

ENGINE - DISMANTLING/ASSEMBLY



Installing Engine in Horizontal Stand
Figure 406

(4) Unfasten the engine mount and adapters and lift the engine clear of the stand.

B. Installation

(1) Secure two PWA 8664 Adapters in upright supports of PWA 8740 Adapter Assembly at turbine nozzle location on stand. Secure PWA 10903 Support to PWA 8740 Adapter Assembly at both ends.

NOTE: PWA 16375 Mounts may be used to support engine at exhaust case instead of nozzle case.

(2) Secure two PWA 8665 Adapters in upright supports of PWA 8740 Adapter Assembly at compressor intermediate case location on stand.

(3) Attach the PWA 16220 Adapter to 12 o'clock holes on the intermediate case.

(4) Pass PWA 8663 Saddle under and around turbine nozzle case so that saddle contacts necked-down surface of case.

(5) Attach PWA 10859 Sling to lifting adapter and saddle. Using chain hoist, lift engine from container.

(6) Lower engine to PWA 10860 Stand and secure mounts and adapters.

CAUTION: BEFORE REMOVING PWA 10859 LIFTING SLING, ENGINE MUST BE ADEQUATELY SUPPORTED BY BOTH VERTICAL SUPPORTS.

(7) Remove the PWA 10859 Lifting Sling and the PWA 16220 Adapter from the engine.

16. Removal/Installation of the Oil Filter Housing

A. Removal

(1) If not already removed, remove bolts and locknuts securing oil filter housing legs to intermediate case mount ring.

(2) Remove two internal spacers positioning legs of oil adapter and filter housing.

(3) Remove bolts, washers, and spacers securing filter housing outside leg to clevis mounted on bracket on lower right front flange of intermediate case. Remove filter housing.

B. Installation

(1) Position oil filter housing to lower right location of intermediate case mount ring area inserting inner legs of housing between intermediate case rings and legs of oil adapter.

(2) Align holes of mount rings, filter housing, and oil adapter; then insert internal spacers (small ID inward) from inside through legs of oil adapter and then through legs of oil filter housing. Secure buildup by inserting bolts through mount rings of intermediate case and installing nuts on inside of legs. Tighten bolts and nuts to recommended torque.

NOTE: Install bracket under bolt head of rear bolt to support fuel tube clip.

(3) Position front leg of filter housing to clevis mounted on bracket on lower right front flange of intermediate case.

(4) Install two spacers in clevis hole; then position washer on each side of clevis. Install washer under bolt head and insert bolt through leg of filter housing and through assembled clevis. Install locknut and tighten bolt and nut to recommended torque.

17. Removal/Installation of the Main Oil Filter Element Assembly

See Figure 407.

A. Removal

(1) Remove nuts securing main oil filter cover to main oil filter housing assembly.

NOTE: On covers which incorporate puller grooves, engage PWA 30643 Puller in grooves and, using knocker action, remove cover.

(2) Remove the main oil filter element.

B. Installation

(1) Coat new packing with engine oil and insert it on groove of cover.

(2) Install main oil filter element assembly into main oil filter housing.

(3) Secure element assembly with washers and nuts. Tighten nuts to recommended torque.

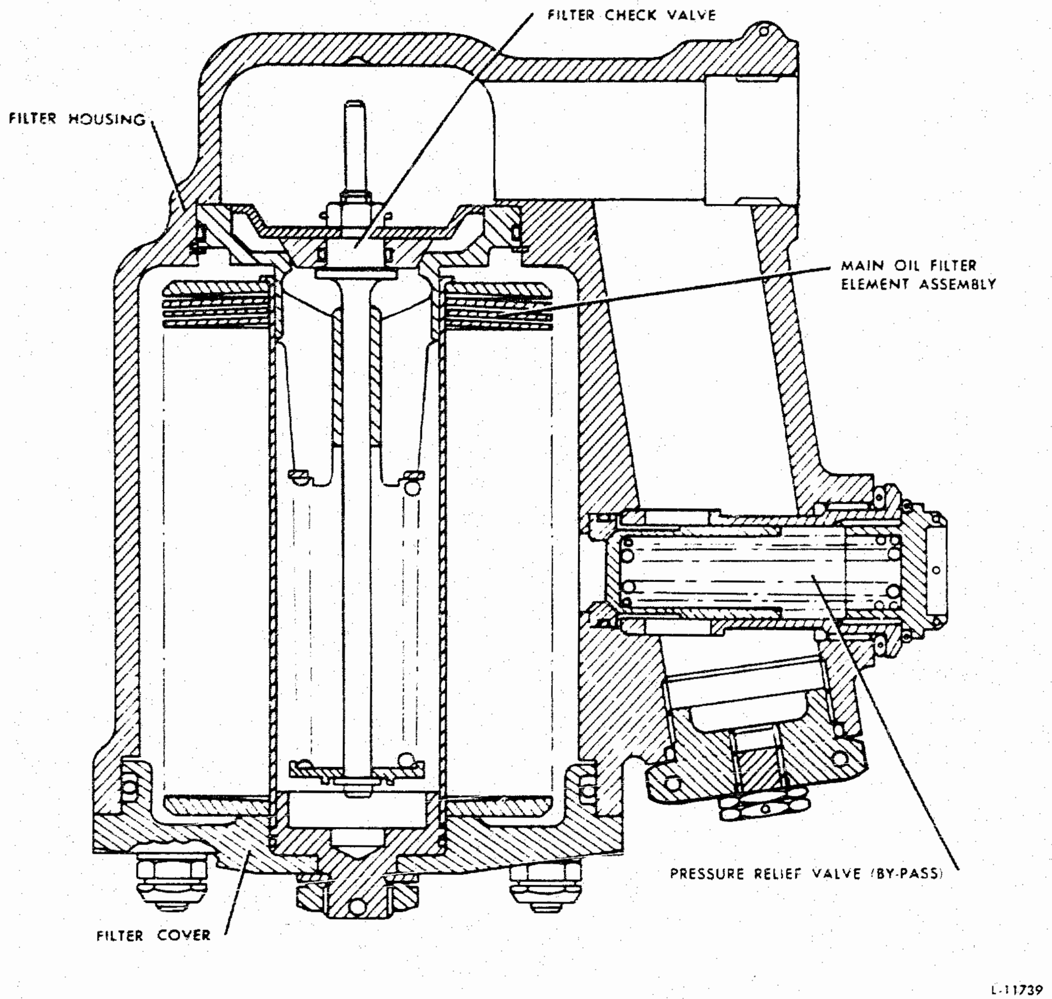
18. Disassembly/Assembly of the Main Oil Filter Element Assembly

See Figure 408.

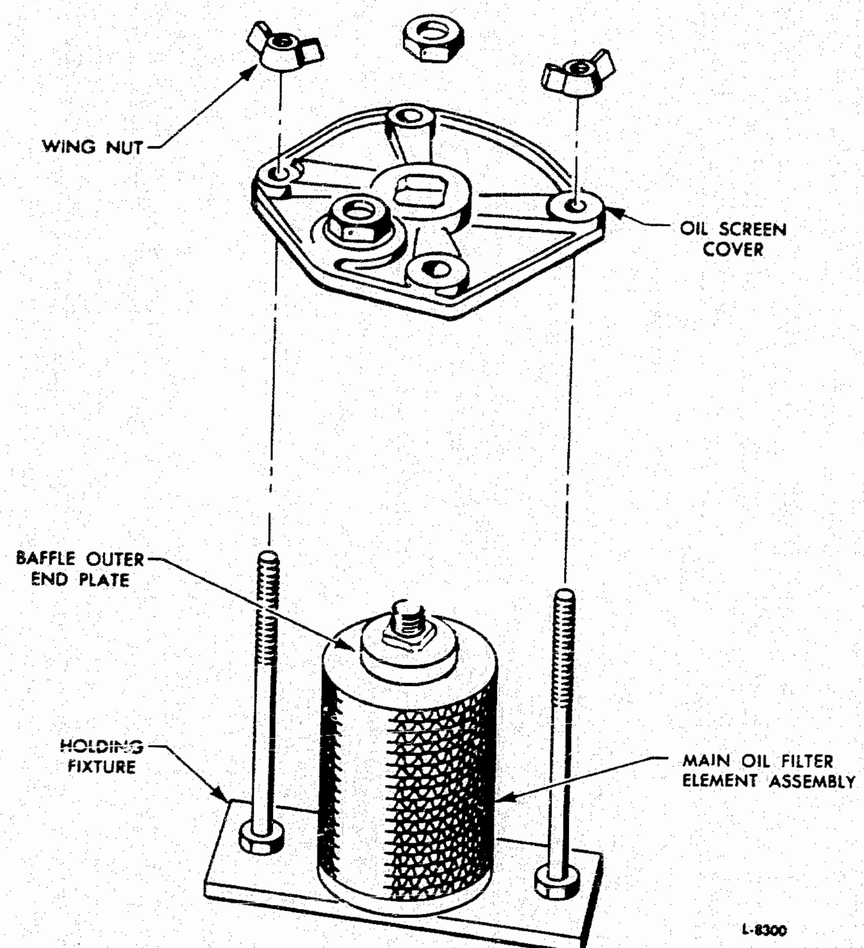
A. Disassembly

(1) Position element in PWA 7153 Fixture; then remove off-center plug from bushing in oil filter cover.

CAUTION: FILTER ELEMENT MUST BE INSTALLED IN FIXTURE PRIOR TO REMOVING COVER NUT TO PREVENT STACKED SCREENS AND SPACERS FROM FLYING OFF UNDER THEIR OWN SPRING PRESSURE.



Oil Filter Housing
Figure 407



Aligning and Installing Main Oil
Filter Element in Fixture
Figure 408

(2) Remove cotterpin and slotted nut securing cover to inner element.

(3) Carefully remove filter cover from fixture; then slide off screens and spacers onto suitable cleaning rod.

B. Assembly

(1) With inner element installed in PWA 7153 Fixture, install outlet spacers, screens, and inlet spacers on inner element so that an outlet spacer will be at both ends and each screen will be between an outlet spacer and an inlet spacer.

(2) Install spacer end plate on assembled spacers and screens.

(3) Place main oil filter cover, slot over shank, on inner filter element.

<u>CAUTION:</u> COMPLETE SETS OF PARTS CONSISTING OF TWO SCREENS AND ONE EACH OF THE INLET AND OUTLET SPACERS MUST BE ADDED OR REMOVED, IF REQUIRED, SO THAT THE SCREENS AND SPACERS CANNOT BE ROTATED BY HAND WHEN THE CENTER SHEAR NUT IS TIGHTENED WITH A TORQUE SUFFICIENT TO SEAT THE ELEMENT END SOLIDLY AGAINST THE COVER.

(4) Install washer and slotted shear nut securing cover to inner element and torque nut to 275 lb. in. minimum to 375 lb. in. maximum.

(5) Insert cotterpin in shear nut on center shaft of inner element.

(6) Place packing on bushing and install bushing in off-center hole in cover. Tighten bushing to recommended torque. Place packing on plug and install plug in bushing. Tighten plug to recommended torque. Lockwire plug to cover.

(7) Check to be sure that cover is seated against end plate and screens and spacers cannot be rotated by hand. If necessary, remove cover and add or remove sets of screens and spacers as directed above until requirements are met. Remove assembled element from fixture.

19. <u>Removal/Installation of the Oil Pressure Relief Valve (By-Pass)</u>.

See Figure 407.

A. Removal

(1) Remove relief valve plug and spring from relief valve liner.

(2) Remove relief valve liner and valve from filter housing.

B. Installation

(1) Install relief valve, gasket and relief valve liner into oil filter housing.

(2) Insert spring into well of relief valve.

(3) Place a gasket on the relief valve liner and install the plug. Tighten the plug to the recommended torque.

20. Removal/Installation of the Oil Pump

See Figure 34, Section 72-0, Description and Operation.

A. Removal

NOTE: The fuel control must be removed prior to removal of the oil pump.

(1) Unfasten the locknuts and washers securing the oil pump front body to the gearbox front housing.

(2) Remove the lockwire from the two nuts (adjacent to the fuel control drive pad) on the front face of the oil pump and remove the nut and washer closest to the pump cover positioning pin.

CAUTION: DO NOT REMOVE THE REMAINING THREE NUTS EXCEPT THE NUT DIAGONALLY OPPOSITE MAY BE REMOVED IN PLACE OF THE ONE ABOVE.

(3) Carefully attach the PWA-2536 Puller to the extended threads of the bolt from which the above nut was removed. Using knocker action remove the oil pump from its cavity in the gearbox front housing.

NOTE: The coupling may remain splined to the hydraulic pump drive gearshaft or stay splined to the end of the oil pump driveshaft when removing the oil pump assembly complete.

B. Installation

(1) Moisten the oil pump packings with engine oil and place them in the oil pump rear and front body grooves, and in the rear body spacer assembly groove.

(2) Insert the oil pump assembly in the gearbox front housing.

NOTE: Be careful that the oil pump coupling properly engages the matching splines of the hydraulic pump drive gearshaft in the gearbox housing, and those of the oil pump drive shaft.

(3) Align the oil pump cover with the positioning pin and bolt holes.

(4) Secure the oil pump to the gearbox front housing with the washers and locknuts. Tighten the locknuts to the reoommended torque.

21. Disassembly/Assembly of the Oil Pump

See Figure 409.

A. Disassembly

(1) Unfasten the nuts securing the oil pump bodies together and remove the washers and bolts.

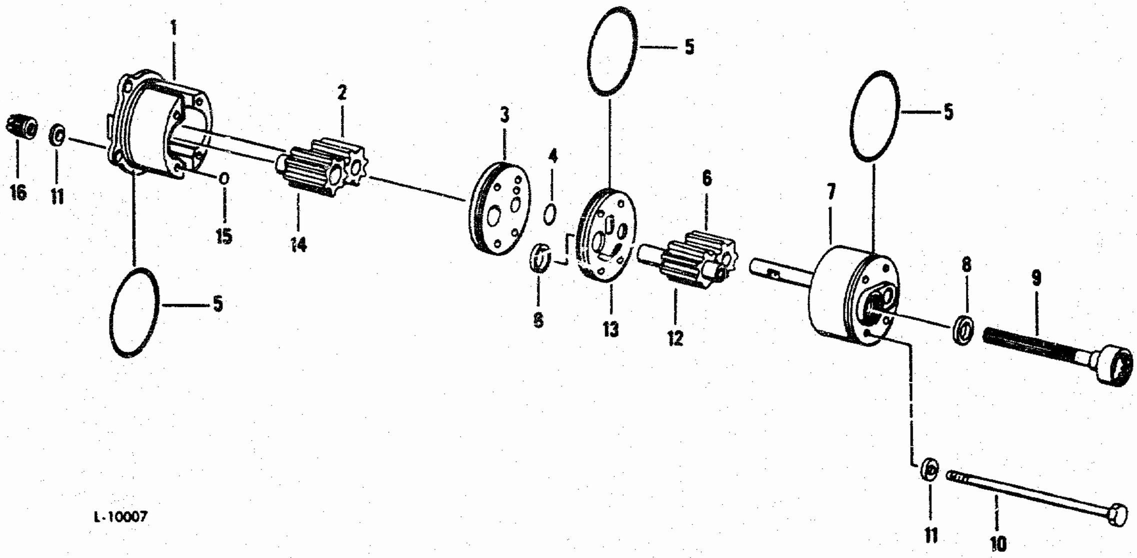
(2) Remove the front oil pump body and the four packings.

(3) Remove the oil pump gearshaft.

(4) Remove the oil pressure pump spur gear.

(5) Remove the front oil pump body spacer.

(6) Remove the rear oil pump body spacer assembly; then remove the seal and the packing from the spacer.



1. FRONT OIL PUMP BODY
2. OIL PUMP SPUR GEAR
3. OIL PUMP BODY FRONT SPACER
4. OIL PUMP BODY REAR SPACER PACKING
5. OIL PUMP PACKING
6. OIL PUMP SPUR GEAR
7. REAR OIL PUMP BODY ASSY OF
8. OIL PUMP BODY SEAL
9. OIL PUMP DRIVE SHAFT
10. OIL PUMP BODY BOLT
11. OIL PUMP BODY BOLT WASHER
12. OIL PUMP DRIVE SPUR GEARSHAFT
13. OIL PUMP BODY REAR SPACER ASSY
14. OIL PUMP GEARSHAFT
15. OIL PUMP FRONT BODY PACKING
16. OIL PUMP BODY BOLT NUT

NOTE: PARTS MUST BE ASSEMBLED SO THAT THE GEARS WILL ROTATE FREELY.

Main Oil Pump

Figure 409

(7) Remove the oil pump drive spur gearshaft.

(8) Remove the oil pump spur gear.

(9) Remove the oil pump drive shaft from the rear oil pump body assembly. Remove the seal from the rear body.

B. Assembly

See Figure 409.

(1) Position the oil pump rear body, oil pump drive shaft opening up, on a bench; then, place a new seal on the PWA-10381 Drift with the seal element up. Install the pilot of the drift into the bore of the oil pump rear body and push the seal into position to seat. Remove the drift. Lubricate the inside of the seal with engine oil.

(2) Position the oil pump rear body assembly (idler shaft end up) on a bench; then lubricate the inside of the seal with engine oil.

(3) Install the oil pump spur gear over the rear body idler shaft and the oil pump drive spur gearshaft in the seal (internal splines up) to seat in the oil pump rear body.

(4) Place the oil pump rear body spacer on a bench, seal opening up; then place a new seal on the PWA-10381 Drift with the seal element up. Install the pilot of the drift into the base of the spacer and push the seal into position to seat. Remove the drift. Lubricate the inside of the seal with engine oil.

(5) Place a packing in the ID of the idler shaft opening in the rear body spacer and install the spacer assembly over the idler shaft and oil pump drive spur gearshaft to seat on the oil pump rear body.

(6) Install the oil pump front body spacer over the idler shaft and gearshaft to seat on the oil pump rear body spacer assembly.

(7) Install the oil pump spur gear over the idler shaft and the oil pump gearshaft over the installed oil pump drive spur gearshaft to seat on the oil pump front body spacer.

(8) Place the packings in the four bottom openings in the oil pump front body and install it over the idler shaft and the oil pump gearshaft to seat on the oil pump front body spacer.

(9) Install the four oil pump assembly bolts and washers through the assembled oil pump, boltheads in rear, and secure with the nuts. Tighten the nuts hand tight.

(10) Install the oil pump drive shaft through the oil pump rear body to seat the shaft shoulder on the gearshaft and to engage the internal splines of the oil suction and oil pressure gearshafts. Rotate the drive shaft to make certain the gears rotate freely inside the oil pump.

NOTE: SB 4453 provides, as additional equipment, a positive lubricated hydraulic pump drive spline. SB 4453 provides a reworked and re-identified oil pump drive shaft that must be used with a reworked and re-identified hydraulic pump drive spur gearshaft.

CAUTION: CHECK TO MAKE CERTAIN THAT THE GEARS CONTINUE TO ROTATE FREELY AFTER TIGHTENING THE NUTS.

(11) Tighten four nuts to recommended torque and lockwire.

22. Removal/Installation of the Oil Filter Check Valve

See Figure 407.

A. Removal

(1) Unfasten the retaining ring which secures the oil filter valve seat to the oil filter housing.

(2) Remove the oil filter valve seat (with disks and stem) from the filter housing.

(3) Remove the dowel pin from the end of the valve stem and slide off the seat, spring, and washer.

(4) Remove the cotterpin from the nut and remove the nut from the shouldered end of the valve stem.

(5) Remove the upper and lower disks from the stem.

B. Installation

(1) Coat a new packing with oil and install the oil filter valve lower disk onto the stem, conical side toward the shoulder of the stem.

ENGINE - DISMANTLING/ASSEMBLY

(2) Install the oil filter valve upper disk on the stem against the lower disk, concave side of the disk away from the lower disk.

(3) Install the nut on the stem and tighten to the recommended torque. Install the cotterpin in the nut and bend to secure.

(4) Slide the build-up stem down into the large ID end of the oil filter valve seat.

(5) Place the washer against the lower end of the valve seat; then install the spring against the washer on the stem.

(6) Install the spring seat over the stem and secure the spring and seat on the valve stem with the dowel.

(7) Coat a new packing with engine oil and position it in the groove of the filter valve seat.

(8) Install the assembled oil filter valve in the oil filter housing.

(9) Secure the valve in the housing by installing the retaining ring.

23. Removal/Installation of the Accessory and Component Drives Gearbox

A. Removal

(1) Remove both hydraulic pad covers from each end of the accessory and component drives gearbox; then install the PWA-16566 (Left) and PWA-16567 (Right) Brackets to each of the pads and secure with the cover's retaining nuts.

(2) Attach the PWA-6580 Sling to each of the bracket spools and take up the slack.

(3) Remove the bolts securing the locks retaining the pins in the diffuser case positioning bracket and the accessory and component drives bearing housing; then using a screwdriver or similar tool, remove the locks and the pins.

(4) Remove the two bolts securing the locks to the brackets attached to the diffuser case front flange.

ENGINE - DISMANTLING/ASSEMBLY

(5) Using the chain hoist, adjust the accessory and component drives gearbox to take its load off of the pins adjacent to the bolts removed from the diffuser case brackets.

(6) Using a screwdriver or similar tool, pry the pins and locks from the brackets attached to the diffuser case.

(7) Position a dolly having small casters under the gearbox and lower the gearbox to the dolly. Remove the sling from the spools of the brackets and withdraw the accessory and component drives gearbox under the horizontal stand.

CAUTION: BECAUSE THE ANGULAR ENGAGEMENT OF THE COUPLING TO THE MAIN ACCESSORY COMPONENT DRIVE SHAFT, THE GEARBOX DOES NOT DROP VERTICALLY UNTIL THE GUIDE IN THE COUPLING IS COMPLETELY OUT OF THE ID OF THE SHAFT. THEREFORE, EXERT PRESSURE ON THE REAR OF THE GEARBOX TOWARDS THE FRONT OF THE ENGINE, TO AID THE GUIDE IN THE COUPLING TO DISENGAGE FROM THE ID OF THE SHAFT DURING INITIAL LOWERING OF THE GEARBOX.

(8) Reinstall the sling to the bracket spools and raise the gearbox; then install the PWA-16177 Support to the alternator drive pad on the front of the gearbox using engine bolts.

(9) Install the gearbox in the PWA-16514 Stand and secure with the ball-lok pins.

(10) Remove the accessory and component drive shaft from inside the diffuser case six o'clock strut.

NOTE: Wrap the shaft in protective paper to prevent damage and contamination to the splines.

B. Installation

(1) Coat the splines with Lubriplate No. 130A or its equivalent; then install the component drive shaft inside the diffuser case six o'clock strut and into its mating spline in the main accessory component drive gearshaft.

(2) With the hydraulic pad covers on each end of the accessory and component drives gearbox removed, install the PWA-16566 (Left) and PWA-16567 (Right) Brackets to each pad and secure them with the cover's retaining nuts.

(3) Using PWA-6580 Sling and a hoist, raise the gearbox from the PWA-16514 Stand and remove the PWA-16177 Support to the alternator drive pad on the front of the gearbox.

(4) Position the gearbox assembly in flight position on a dolly having casters; then remove the sling.

(5) Using the dolly, position the gearbox assembly under the six o'clock strut of the diffuser case and reinstall the sling to the bracket spools.

(6) Coat the splines of the coupling in the gearbox assembly with Lubriplate No. 130A or its equivalent, and with the hoist, raise the gearbox assembly from the dolly while positioning the guide of the coupling in the ID of the component drive shaft in the diffuser case strut, carefully install the gearbox, placing the lugs of the gearbox assembly bracket in the diffuser case positioning bracket.

CAUTION: BECAUSE OF THE ANGULAR ENGAGEMENT OF THE COUPLING TO THE MAIN ACCESSORY COMPONENT DRIVE SHAFT, THE GEARBOX ASSEMBLY CANNOT BE RAISED VERTICALLY AFTER THE COUPLING HAS ENTERED THE ID OF THE SHAFT. THEREFORE, EXERT PRESSURE ON THE FRONT OF THE GEARBOX TOWARD THE REAR OF THE ENGINE, TO AID THE GUIDE IN THE COUPLING TO ENGAGE IN THE ID OF THE SHAFT DURING INITIAL RAISING OF THE GEARBOX.

(7) Align the holes in the diffuser case brackets with those in the accessory and component drives bearing housing and insert the retaining pins. Install the locks on the pins; then secure the locks with the bolts. Tighten the bolts to the recommended torque.

(8) Using the chain hoist, align the holes of the gearbox links to those in the brackets on the diffuser case front flange and insert the retaining pins. Install the locks on the pins; then secure the locks with the bolts. Tighten the bolts to the recommended torque. Lockwire the bolts.

(9) Remove the brackets and the sling.

24. Removal/Installation of Accessory and Component Drives Gearbox Breather Adapter (JT3D-1, D-3 and D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7) or Breather Elbow (JT3D-1, D-3 and D-3B Douglas)

A. Removal

(1) Remove locknuts securing accessory and component drives gearbox breather adapter (JT3D-1, D-3 and D-3B Boeing, JT3D-1-MC6, and JT3D-1-MC7) or breather elbow (JT3D-1, D-3 and D-3B Douglas) to oil pump pad on rear gearbox housing.

(2) Remove breather adapter or breather elbow.

(3) Remove plug and packing from breather adapter or unfasten and remove bolts, washers, and locknuts securing cover to elbow; then remove cover and gasket.

B. Installation

(1) For the JT3D-1, D-3 and D-3B (Boeing), JT3D-1-MC6, and JT3D-1-MC7, using new packing, install plug on accessory and components drives gearbox adapter; then tighten plug to recommended torque and secure with lockwire or for JT3D-1 (Douglas) using new gasket, install accessory and component drives gearbox elbow cover on elbow and secure it with bolts, washers, and locknuts and tighten to recommended torque.

NOTE: Install washers under bolt heads and under nuts.

(2) Position adapter or elbow on pad at oil pump location on rear gearbox housing and secure it using washers and locknuts. Tighten locknuts to recommended torque.

25. Removal/Installation of the Oil Pressure Relief Valve

See Figure 410.

A. Removal

(1) Using wrench to prevent pressure relief valve body from turning, remove relief valve plug. Discard packing.

(2) Remove pressure relief valve assembly from gearbox front housing using standard wrench. Discard packing.

B. Installation

(1) Place new packing on relief valve body flange and thread relief valve body assembly into threaded bore located on lower right side of accessory and components drives gearbox front housing. Tighten valve body to recommended torque.

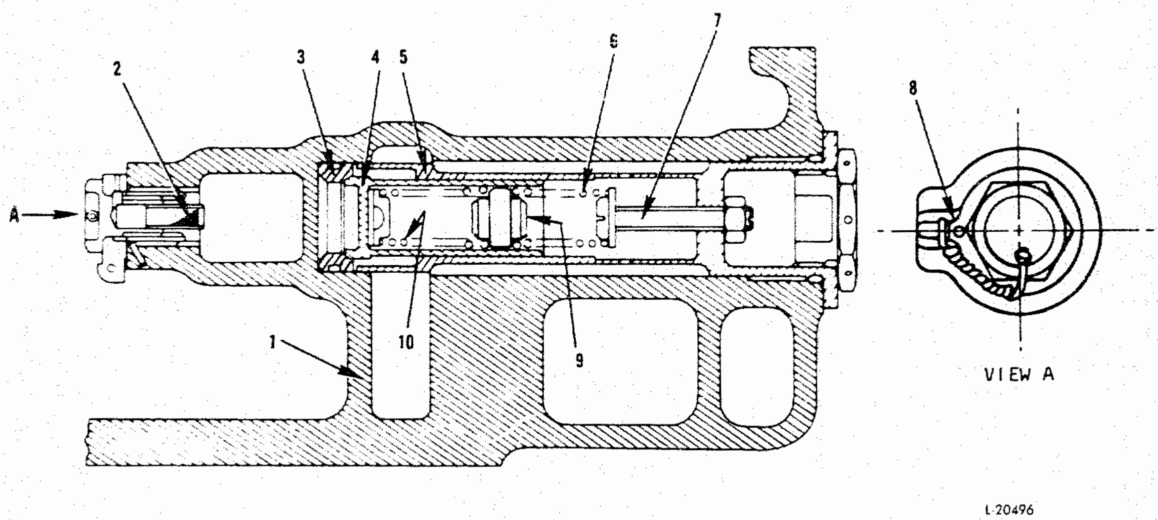
(2) Place a packing on the relief valve plug and thread it into the ID of the relief valve body. Tighten the plug to the recommended torque. Lockwire the plug.

26. Disassembly/Assembly of the Oil Pressure Relief Valve

A. Disassembly

(1) Remove the valve from the valve body; then remove the spring positioning plate, spring seat, and the spring.

(2) Remove the relief valve adjusting screw from the nut and remove them both from the valve body.



1. Gearbox
2. Strainer
3. Valve Seat
4. Valve
5. Valve Body
6. Outer Spring
7. Adjusting Screw
8. Do Not Lockwire Over Jet Port
9. Intermediate Spring Seat
10. Inner Spring

Oil Pressure Relief Valve
Figure 410

(3) Position the expander of PWA-16359 Puller into the valve bore in the gearbox front housing to pass through the seat behind the valve seat; expand the puller securely in position and, holding the body of the puller in position, turn the jamnut and remove the valve seat from the housing bore. Remove the puller. Discard the gasket.

B. Assembly

(1) Moisten the oil pressure relief valve seat packing with engine oil, and place it in the valve seat groove.

(2) Position the relief valve seat on the pilot of PWA-16358 Drift and insert it into the bottom right side of the gearbox front housing. Drift the valve seat to bottom in the cavity. Remove the drift.

CAUTION: AFTER INSTALLING THE SEAT AND PACKING INTO THE HOUSING CAVITY, USE A STRONG LIGHT AND CHECK TO SEE THAT THE PACKING REMAINED IN THE GROOVE AND THAT NO ROLL-DOWN OF ANY PART OF THE PACKING HAS OCCURRED.

(3) Place relief valve positioning plate in relief valve and valve spring seat on plate. Position inner spring in valve to bottom on the spring seat; then install intermediate spring seat and the outer spring. See Figure 410.

(4) Thread the adjusting screw to full depth in the body; then install the nut on the screw.

(5) Position the assembled relief valve into the relief valve body to seat the spring on the adjusting screw.

27. Removal/Installation of the Oil Scavenge Pump (Inlet) Strainer

A. Removal

(1) Provide a suitable container to catch the draining oil; then unfasten and remove the two bolts retaining the oil scavenge pump strainer at the bottom of the accessory drives housing and remove the strainer.

(2) Discard the oil strainer packing and clean the strainer.

B. Installation

(1) Install a new oil strainer packing on the strainer and install strainer in accessory drive housing.

28. Removal/Installation of Fuel Pump Drive Front Oil Seal/Engines Incorporating Fuel Pump Drive Spline Pressure Oil Lubrication

A. Removal

(1) Remove seal retaining ring (P/N 541170) from ID of retainer.

(2) Drill three one-eighth inch holes approximately 120° apart centered in the metal face of the seal.

(3) Install three self-tapping screws (No. 8 Blunt End recommended).

(4) Using suitable puller remove seal by pulling on the three screws.

CAUTION: LIMIT PENETRATION OF DRILL AND SCREWS TO 0.250 INCH OR LESS TO AVOID DAMAGE TO RETAINER.

B. Installation

(1) Place seal (P/N 436174) in retainer and over end of fuel pump shaftgear.

(2) Carefully seat seal in retainer.

(3) Replace seal retaining ring in retainer.

CAUTION: SEAL RETAINER (P/N 566070) CANNOT BE REMOVED BEFORE GEARBOX IS SPLIT AND FUEL PUMP DRIVE SPLINE LUBRICATION NOZZLE REMOVED.

28A. Starter Drive Oil Seal Replacement

A. Removal of Seal and Housing Assembly

(1) Remove starter, or drive pad cover from gearbox.

(2) Remove drain plug and drain gearbox.

(3) Remove snapring securing drive seal housing assembly in gearbox.

(4) Using PWA-16157 Puller, insert puller jaws into seal housing and remove housing. Remove packing from seal housing outer groove.

B. Seal Replacement

(1) Place seal housing assembly into PWA-16161 Base, large ID down, so housing engages locating diameter provided on base. Using PWA-7143 Drift, press seal out of housing.

ENGINE - DISMANTLING/ASSEMBLY

(2) Place seal housing on bench, place seal onto housing and locate PWA-6676 Drift on face of seal. Drift oil seal into position.

C. Installation of Seal Housing Assembly

(1) Place a packing, lubricated with petrolatum, in starter drive oil seal housing outer groove.

(2) Position seal housing assembly over starter drive coupling and drift to seat on shoulder of counter-bore in gearbox rear housing.

(3) Install snapring securing oil seal housing assembly to gearbox rear housing.

(4) Place a gasket on starter drive cover and secure gasket and cover to starter drive pad with washers and locknuts. Tighten locknuts to recommended torque.

(5) Install drain plug with new seal into gearbox, tighten to recommended torque and lockwire.

28B. Alternator Drive Oil Seal Replacement

A. Removal of Seal and Housing Assembly

(1) Remove locknuts and washers securing alternator drive pad cover to gearbox and remove cover and gasket.

(2) Remove drain plug and drain gearbox.

(3) Remove snapring securing drive oil seal housing assembly in gearbox.

(4) Using PWA-16157 Puller, insert puller jaws into seal housing and remove housing. Remove packing from seal housing outer groove.

B. Seal Replacement

(1) Place seal housing assembly into PWA-16161 Base, large ID so housing engages locating diameter provided on base. Using PWA-7143 Drift, press seal out of housing.

(2) Place alternator drive housing on bench, place seal onto housing and locate PWA-6676 Drift on face seal. Drift oil seal into position.

C. Installation of Seal Housing Assembly

(1) Place a packing in alternator drive oil seal housing outer groove.

(2) Position seal housing assembly over alternator drive gearshaft and to seat on shoulder of counterbore in gearbox front housing.

(3) Install snapring securing oil seal housing to gearbox front housing.

(4) Place a gasket on alternator drive cover and secure gasket and cover to pad with washers and locknuts. Tighten locknuts to recommended torque.

(5) Install drain plug with new seal into gearbox, tighten to recommended torque and lockwire.

28C. Tachometer Drive Oil Seal Replacement

See Figures 410A and 410B.

A. Removal of Seal and Housing Assembly

(1) Remove tachometer drive pad cover from gearbox.

(2) Remove drain plug and drain gearbox.

(3) Insert PWA-3790-50 Puller into tachometer drive gearshaft ID. Tightening knurled collar, secure puller lips to gearshaft ID. Using knocker action, remove tachometer drive housing from gearbox rear housing cavity and place on bench housing flange down.

(4) Remove tachometer gearshaft bearing lockring from housing.

(5) Using a drift, remove gearshaft and bearings from housing.

(6) Remove retaining ring securing inner race of first bearing to gearshaft.

(7) Using PWA-16338 Puller, locate jaws between two bearings with puller jaws contacting under face of first bearing and pilot of jackscrew in ID of gearshaft. Turn jackscrew and remove first bearing from gearshaft. Remove puller.

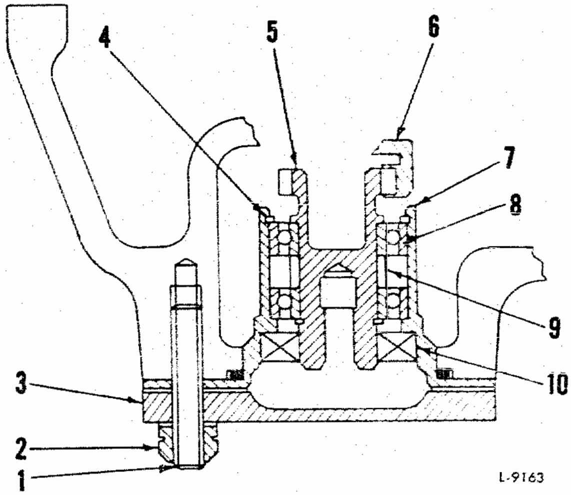
(8) Remove sleeve spacer from gearshaft.

(9) Position jaws of puller in cut-outs in shoulder of gearshaft to contact under side of inner race of second bearing. Turning jackscrew, with pilot in ID of gearshaft, remove bearing from gearshaft. Remove puller.

NOTE: Provide container to store bearings until reassembly.

(10) Place tachometer drive housing (flange face down) on bench. Using fiber drift, remove seal from housing.

ENGINE - DISMANTLING/ASSEMBLY



1. Stud
2. Locknut
3. Cover
4. Lockring
5. Tachometer Drive Gearshaft
6. Tachometer Drivegear
7. Bearing Housing
8. Bearing (2)
9. Spacer
10. Seal

Tachometer Drive Gearshaft Assembly

Figure 410A

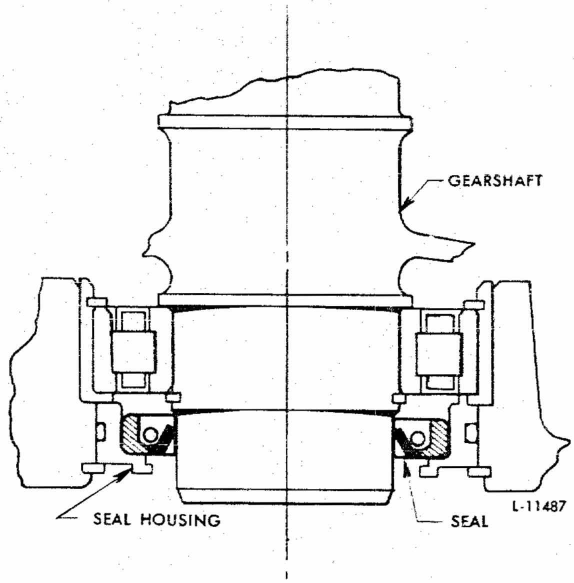
B. Installation of Gearshaft, Bearings and Oil Seal

(1) Position tachometer drive gearshaft, gear end down, on an arbor press. Locate first bearing on end of gearshaft and, using PWA-16337 Drift, press bearing into position to seat on gearshaft shoulder. Remove drift. See Figure 410A.

(2) Install bearing spacer to seat on first bearing.

(3) Install second bearing in same manner as first bearing. Remove drift and assembly from arbor press.

(4) Secure bearings to gearshaft with retaining ring.



Typical Lip Type Oil Seal

Figure 410B

(5) Position tachometer drive gearshaft housing (flange down) on a bench. Drive gearshaft and bearings into housing to seat on housing shoulder.

(6) Install lockring in housing.

(7) Position tachometer drive housing on PWA-30017 Base then lubricate tachometer drive oil seal. Place PWA-14047 Guide into square hole in tachometer drive gearshaft; then place oil seal (element up) over guide and, using PWA-6841 or PWA-30016 Drift, seat seal on housing shoulder. See Figure 410B. Remove drift and guide.

(8) Place a packing in bottom side of tachometer drive gearshaft housing; then insert housing assembly into four sided pad cavity in gearbox rear housing, meshing tachometer drive gearshaft with tachometer drivegear. See Figure 410A.

(9) Position a gasket on tachometer pad and install cover. Secure cover with washers and locknuts. Tighten locknuts to recommended torque.

28D. Hydraulic Pump Drive Oil Seal Replacement

A. Removal of Seal and Housing Assembly

(1) Remove locknuts and washers securing hydraulic pump drive cover to gearbox rear housing; remove cover and gasket.

(2) Remove drain plug and drain gearbox.

(3) Remove retaining ring securing hydraulic pump drive oil seal housing in gearbox.

(4) Using PWA 16157 Puller, insert puller jaws into seal housing and remove housing. Remove packing from seal housing outer groove.

(5) Using drift, remove oil seal from oil seal housing.

B. Seal Replacement

(1) Place PWA 16295 Base on bench; then position seal housing on base (large ID up).

(2) Moisten new hydraulic pump drive lip type oil seal with engine oil and position it on PWA 16158 Drift with open face of seal up toward drift flange.

(3) Install drift and seal into seal housing with pilot on drift engaging hole in base.

(4) Using fiber mallet, seat seal in seal housing. Remove drift and housing from base.

C. Installation of Seal and Seal Housing Assembly

(1) Place PWA-16295 Base on a bench; then position hydraulic pump drive oil seal housing on base, large ID up.

(2) Lubricate hydraulic pump drive oil seal with petrolatum and position it on PWA 16158 Drift with open face of seal up towards drift flange.

(3) Install drift and seal into seal housing with pilot on drift engaging hole in base.

(4) Using a fiber mallet, seat seal in seal housing. Remove drift and housing from base.

(5) Place a packing in hydraulic pump drive oil seal housing outer groove.

(6) Position PWA 3095 Guide into splined ID of hydraulic pump drive gearshaft to seat on shoulder of guide. Position oil seal housing assembly into gearbox cavity and over guide to contact ID of oil seal. Drift housing assembly to seat on liner shoulder. Remove guide from gearshaft.

ENGINE - DISMANTLING/ASSEMBLY

(7) Install snapring securing oil seal housing assembly to gearbox rear housing.

(8) Place a gasket on hydraulic pump drive cover and secure gasket and cover to hydraulic pump drive pad with washers and locknuts. Tighten locknuts to recommended torque.

NOTE: SB 4453 provides, as additional equipment, a positive lubricated hydraulic pump drive spline. If gearbox housing assembly incorporates this system by SB 4453 but will be used on an engine that does not incorporate a hydraulic pump assembly, hydraulic pump drive gearshaft opening in gearbox must be covered by a plug, packing, screw, and key washer prior to installing hydraulic pump drive cover. See Figure 410B-1. Screw will be torqued to 24 - 36 lb.-in.

28E. Fuel Pump Drive Front Oil Seal Replacement

A. Removal of Seal and Seal Housing Assembly

(1) With fuel pump removed from gearbox, remove snapring securing oil seal housing assembly in gearbox.

(2) Using PWA-16157 Puller, insert puller jaws into seal housing and remove housing assembly.

(3) Place seal housing assembly on bench and remove snapring securing oil seal. Using drift remove oil seal.

B. Seal Replacement

(1) Place PWA-16295 Base on bench; then position seal housing on base, large ID up.

(2) Moisten new fuel pump drive lip type oil seal with engine oil and position it on PWA-16158 Drift with open face of seal up toward drift flange.

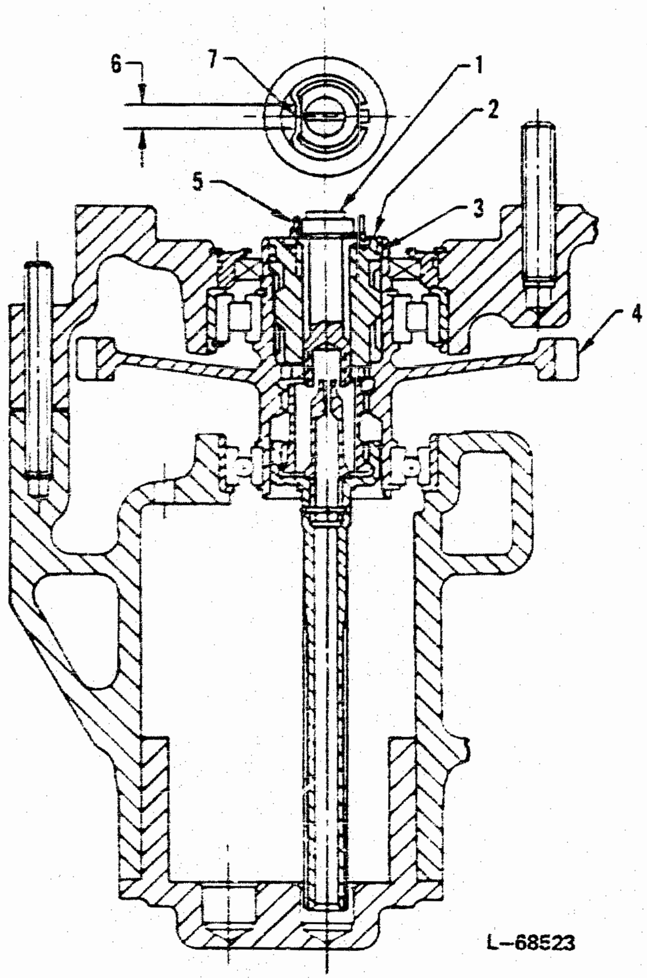
(3) Install drift and seal into seal housing with pilot on drift engaging hole in base.

(4) Using fiber mallet, seat seal in seal housing. Remove drift and housing from base.

C. Installation

(1) Place packing in fuel pump drive oil seal housing outer groove.

(2) Position PWA-3095 Guide into splined ID of fuel pump drive gearshaft to seat on shoulder of guide. Position oil seal housing assembly into liner and over guide to contact ID of oil seal. Drift housing assembly to seat on gearshaft ball bearing outer race. Remove guide from gearshaft ball bearing outer race. Remove guide from gearshaft.



1. PN 765022 Screw, Torque To 24 - 36 lb.-in.
2. PN 765020 Plug
3. MS9388-026 Packing
4. PN 766249 Gearshaft Assembly (Reference)
5. PN 765023 Key Washer
6. 0.200 Inch Minimum
7. Crimp Key Washer After Torquing Screw.

Installation Of Plug, Packing, Screw, And Key Washer
Figure 410B-1

(3) Install snapring securing oil seal housing assembly to liner.

(4) Install suitable protective cover over fuel pump opening of gearbox.

28F. Fuel Pump Drive Rear Oil Seal Replacement

A. Removal

(1) Remove locknuts and washers securing de-oiler pad cover. For Douglas engines, remove oil breather elbow.

(2) Using PWA-16157 Puller, engage puller lugs with puller groove in oil seal housing. Turn puller jackscrew to drive pilot into fuel pump drive gearshaft ID and jack oil seal housing assembly from accessory drive rear housing.

(3) Remove packing and drift oil seal from housing.

B. Seal Replacement

(1) Heat fuel pump drive rear oil seal housing in a hot oil bath. Position oil seal on pilot of PWA-16367 Drift with feather edge of seal facing drift. Place housing in an arbor press. Using press and drift, install and seat oil seal. Remove drift.

NOTE: For gearboxes incorporating fuel pump drive splined lubrication, use PWA-17078 Drift and PWA-10631 Base. After removing oil seal housing from hot oil bath, position it on PWA-10631 Base. Position oil seal on PWA-17078 Drift (feather edge of seal facing drift) and with aid of an arbor press, install and seat oil seal in housing.

C. Installation of Oil Seal Housing Assembly

(1) Install applicable Guide (PWA-16366 or PWA-16930 Guide) in end of fuel pump drive spur gearshaft.

(2) Install packing in recess on OD of oil seal housing.

(3) Slip OD of oil seal over OD of guide and onto OD of gearshaft. Remove guide.

(4) Use PWA-16768 Drift to seat housing and seal.

28G. Fuel Control Drive Oil Seal Replacement

A. Removal

(1) With fuel control removed from gearbox, remove snapring securing oil seal housing assembly in gearbox.

(2) Using PWA-16157 Puller, insert puller jaws into seal housing and remove housing.

(3) Remove packing from seal housing outer groove.

(4) Using drift, remove oil seal from oil seal housing.

B. Seal Replacement

(1) Place fuel control drive oil seal housing (puller groove down) on a bench.

(2) Lubricate fuel control drive oil seal and position it on PWA-16162 Drift with open face of seal up towards drift flange. Place drift and seal on housing and press in until seal bottoms on shoulder in housing. Remove drift.

C. Installation of Oil Seal Housing

(1) Place a packing in fuel control drive oil seal housing outer groove.

(2) Position PWA-13030 Guide into splined ID of fuel control drive gearshaft to seat on shoulder of guide. Position oil seal housing assembly into liner and over guide to contact ID of oil seal. Drift housing assembly to seat on gearshaft ball bearing outer race. Remove guide from gearshaft.

(3) Install snapring securing oil seal housing assembly to liner.

(4) Install suitable protective cover over fuel control opening of gearbox.

28H. Water Injection Pump Drive (Boeing/Fuel Boost Pumps (Douglas) Oil Seal Replacement

A. Removal

(1) Remove locknuts and washers securing water injection pump drive cover from left end drive pad and remove cover.

(2) Remove retaining ring securing oil seal housing.

(3) Remove seal housing assembly using PWA-16463 Puller. Engage jaws of puller in groove in oil seal housing. Turn jackscrew of tool in so that pilot on end of jackscrew contacts end of water injection pump drive bevel gear. Continue to turn jackscrew in to jack oil seal housing out of bearing support.

(4) Place seal housing assembly on top of PWA-16454 Base with oil seal facing down.

(5) Position shoulder of PWA-16453 Drift against rear face of oil seal. Using an arbor press, push oil seal out of oil seal housing assembly.

B. Seal Replacement

(1) Position oil seal on pilot of PWA-16455 Drift.

(2) Install oil seal in seal housing by using an arbor press on the drift.

C. Installation of Seal Housing

(1) Install pilot of PWA-16460 Guide in splined end of water injection pump drive bevel gearshaft.

(2) Install a new lubricated packing on seal housing.

(3) Push seal and housing over guide until seal bottoms in bearing support.

(4) Secure housing with retaining ring.

(5) Position a gasket on drive pad and install cover, making certain that largest hole in cover lines up with shouldered stud on drive pad. Secure cover with washers and locknuts. Tighten locknuts to recommended torque.

281. Removal/Installation of Tachometer Drive Cover, Oil Seal Housing and Oil Seal (N1)

A. Removal

(1) Remove nuts and washers securing tachometer drive cover to four cornered pad on front accessory drive front support; then remove cover and gasket.

(2) Prior to removing oil seal housing, inspect housing area for oil leakage.

(3) Install PWA-7146 Puller jaws in oil seal housing puller groove; then using knocker action, remove tachometer drive oil seal housing and oil seal from front accessory drive front support.

(4) Remove oil seal ring from housing OD.

(5) Inspect carbon seal while it is still in housing. Remove seal from housing only if seal is to be replaced.

(6) Position tachometer drive oil seal housing (front face down) on bench.

(7) Using fiber drift, remove oil seal from housing.

B. Installation

(1) Coat O-ring seal with engine oil and install seal in OD groove of tachometer drive shaftgear seal housing.

(2) Position seal housing on front accessory drive front support tachometer pad, aligning housing flange holes with studs. Using drift, seat housing to bottom of pad.

(3) Position tachometer drive housing on PWA 30017 Base. Install PWA 14047 Guide in square drive of tachometer drive gearshaft; then moisten ID of lip type oil seal with engine oil and position seal on guide (spring toward ball bearings).

(4) Using PWA 6841 or PWA 30016 Drift, seat oil seal on inside shoulder of oil seal housing. Remove drift and guide.

(5) Place gaskets on tachometer and governor pads; then position covers over studs and install washers and locknuts. Torque locknuts.

28J. Removal/Installation of Inlet Cone Support Assembly

A. Removal

(1) Unfasten and remove bolts securing front accessory drive support assembly to No. 1 bearing front support.

(2) Using PWA 17412 Puller mounted on tachometer drive studs, remove front accessory drive support assembly from No. 1 bearing front support.

B. Installation

NOTE: For Douglas installation, SB 4882 reworks/replaces inlet cone support to provide a support with studs and bolts of higher thermal expansion material. New studs must be used as a complete set in new or reworked support. New bolts must be used as a complete set with supports incorporating new studs to obtain full benefit of SB 4882.

(1) On JT3D-1 and JT3D-3 (Douglas) engines, install new lubricated packing on groove on OD of inlet cone support rear flange.

ENGINE - DISMANTLING/ASSEMBLY

(2) Position inlet cone support assembly with its pin aligned with hole on front of inlet case against outer diameter of No. 1 bearing front support.

(3) Install washers, with depressions to fit grooves in support brackets in positions noted at disassembly, and bolts. Tighten bolts to recommended torque and bend tabs of tabwashers up to secure bolts.

NOTE: For Douglas installation, SB 5083 introduces bolt, PN 777363. This bolt is directly interchangeable with bolt, PN AN103818, and it also can be used to replace bolt, PN 755873, if there is a worn lock groove at hole location. However, when replacing bolt, PN 755873, two or more adjacent bolts must be installed to facilitate lockwiring together with wire, PN 586822. Tab on key washer used with bolt, PN 777363, need not be turned up against bolt head.

(4) Install cap on compressor inlet vane air transfer tube located at 10 o'clock position (viewed from front).

28K. Removal/Installation of No. 1 Bearing and Front Accessory Drives Main Gear

A. Removal

(1) Install front compressor locating supports (PWA-16935 Supports) on fan discharge case at approximately 5 and 7 o'clock positions. Adjust screw to engage second stage compressor disk between blades and support compressor rotor.

(2) Unfasten two oil nozzle bolts and remove No. 1 bearing oil nozzle assembly.

(3) Remove two bolts securing No. 1 bearing oil strainer support to No. 1 bearing housing. Remove strainer support and No. 1 bearing oil strainer housing.

(4) Remove "L" shaped oil suction tube from eight o'clock position of bearing front support.

(5) Remove bearing inner race retaining nut rivet.

(6) Position PWA-16031 Wrench on retaining nut. Install PWA-16249 Holder on studs of inlet cone support, engaging front accessory drivegear to prevent rotation of rotor.

(7) Loosen inner race retaining nut with PWA-16031 Wrench. Remove rotor holder and wrench.

(8) If front accessory drivegear is of type secured by snapring, compress snapring clear of bearing inner race retaining nut lip and pull drivegear from hub. Use PWA-16050 Puller to remove drivegear, if necessary.

(9) Remove inner race retaining nut.

(10) If front accessory drivegear is of type held in place by lip of No. 1 bearing retaining nut, not by snapring as in step (8), pull drivegear from hub using PWA-16050 Puller.

(11) Remove rivet, then remove No. 1 bearing outer race retaining nut (left-hand thread) with PWA-16040 Wrench by engaging slots of retaining nut.

NOTE: On JT3D-1MC6 engine, use six PWA-16282 Teeth to adapt wrench to nut.

(12) Remove bolts which secure No. 1 bearing housing to front and rear support.

(13) Using PWA-16043 Puller, remove No. 1 bearing housing (with bearing outer race and rollers).

NOTE: On JT3D-1MC6 engine, use PWA-16281 Puller; for JT3D-1MC7, JT3D-1, and JT3D-3 engines, use PWA-16043 Puller.

(14) Install bearing housing front face down in PWA-30343 Base and drift out outer race and rollers, using PWA-30344 Drift.

CAUTION: DETAIL PARTS OF BEARING MUST BE KEPT IN THEIR ORIGINAL ASSEMBLIES. PROTECT BEARING BY STORING IN A SUITABLE CONTAINER.

(15) Place lips of PWA-8193 Puller in puller groove of No. 1 bearing seal plate and, by turning jackscrews, remove seal plate together with No. 1 bearing inner race.

(16) Reinstall No. 1 bearing housing on No. 1 bearing support.

(17) Install PWA-16039 Spacer (dummy bearing) on front hub (and into housing).

NOTE: Use PWA-8192 Spacer on JT3D-1MC6 engine.

(18) Secure spacer and housing by installing inner race retaining nut handtight using PWA-16031 Wrench.

NOTE: For JT3D-1MC6 engine, use nine PWA-16572 Teeth to adapt PWA-16031 Wrench to nut.

(19) Remove two supports from fan discharge case.

B. Installation

(1) Install front compressor rotor PWA-16935 Locating Supports on fan discharge case at approximately 5 and 7 o'clock positions. Adjust screw to engage second stage compressor disk between blades to support compressor rotor.

(2) Using PWA-16040 Wrench, remove No. 1 bearing outer race retaining nut and, using PWA-3687 Puller, remove PWA-16039 Spacer (dummy bearing) from the No. 1 bearing housing and front compressor front hub.

(3) Remove bolts securing No. 1 bearing housing to front support and remove bearing housing, indexing housing and support for later reassembly in same location. Temporarily secure front and rear supports with short bolts.

(4) Heat bearing housing in hot oil and position housing front face up in PWA-30429 Base.

ENGINE - DISMANTLING/ASSEMBLY

(5) Install bearing outer race and rollers in housing as follows:

(a) Assemble inner and outer race and rollers of bearing assembly, mating serial numbers on both inner and outer races on same side of assembly.

(b) Install bearing assembly in PWA-30430 Drift with serial numbers on inner and outer races facing away from pilot detail of drift.

(c) Position drift and bearing assembly in heated housing and drift bearing into housing. Allow temperature of parts to equalize and then remove drift and inner race.

(6) Install outer race retaining nut using PWA 16040 Wrench, torque nut as follows:

(a) Tighten nut to 2000 lb-in.

(b) Mark location of nut with reference to mating part.

(c) Turn nut through angle of 9° minimum to ±12° maximum.

(d) Loosen nut to 0 lb-in. and repeat set (a).

(e) If mark on nut is in line with or beyond mating part reference mark within 0.050 inch maximum, apply final angle of turn per step (c).

(f) If marks are not within limits, repeat steps (b), (c), and (d) in order, until marks are within limits. Then perform step (e).

(7) Install rivet in outer race retaining nut by inserting it from OD of bearing housing front flange. Flare rivet using PWA 31743 Riveter.

NOTE For engines incorporating No. 1 bearing anti-rotation key, key should not be reinstalled to prevent possible damage from mis-assembly. Slotted bearing, seal and seal seat may be used without key.

(8) Install No. 1 bearing spacer (knife-edge seals to rear) on front compressor front hub.

NOTE: To ensure a continuous seating contact of carbon seal plates and seal spacers, perform following blue check. This check must precede final build-up of bearing seal assembly.

(a) Apply a bluing material to seating surfaces of carbon seal plates and seal spacers build-up.

NOTE: Inside diameters of seal plates and seal spacers do not have to be checked.

(b) Assemble seal plates and seal spacers on hubs and/or shafts, depending on which bearing is being installed.

(c) Wring build-up of seal plates and seal spacers together.

(d) Disassemble build-up and check seating surfaces for continuous contact.

(e) If necessary to obtain a continuous contact, lap the seating surfaces to a finish of RMS 16 or smoother; then recheck contact surfaces using bluing material.

(9) Coat No. 1 bearing seal plate with engine oil and install it (puller groove forward) on compressor front hub against No. 1 bearing spacer.

(10) Install PWA-16044 Compressor against front face of No. 1 bearing seal plate. Compress seal rearward by securing compressor in place with four of bearing housing holes.

NOTE: Before installing No. 1 bearing inner race, spray on a light coat of dgf-123 anti-galling lubricant on hub journal to eliminate scoring of hub at disassembly. Area to be lubricated must be clean and free of oil.

(11) Heat No. 1 bearing inner race in hot oil and, using PWA-7337 Drift, install No. 1 bearing inner race, serail numbers to front, on hub against seal plate.

(12) Lubricate new O-ring and install it in groove on OD of front accessory drivegear: If gear is not snapring-retained type, install gear in front hub, aligning rivet holes in gear with rivet hole in hub.

(13) Install No. 1 bearing inner race retaining nut on front compressor front hub. Tighten it up against bearing handtight, using PWA-16031 Wrench.

NOTE: If necessary, use following procedure to hold rotor. Position PWA-16031 Wrench for No. 1 bearing inner race retaining nut; then install PWA-16249 Holder on studs of inlet cone support, engaging front accessory drivegear to prevent rotor movement (snapring-retained drivegear must be installed as directed below). Wrench must be positioned before holder. Proceed as in step (13), then remove holder and wrench.

(14) Remove PWA 16044 Compressor from No. 1 bearing seal plate.

(15) If front accessory drivegear is snapring-retained type, install it temporarily in hub ID to provide counterforce for torque wrench. Snapring may be temporarily removed from drivegear for convenience.

(16) Attach PWA 16041 Wrench to PWA 18872 Wrench using PWA 20333 Adapter and PWA 20334 Plate. Position assembled wrenches so that PWA 16041 Wrench engages inner race retaining nut and front accessory drivegear. Attach PWA 3755 Hydraulic Pump to ram of PWA 18872 Hydraulic Wrench and tighten inner race retaining nut using following procedure:

(a) Tighten nut to 2000 lb-in.; then turn through angle of 10 degrees minimum to 15 degrees maximum and then loosen to 0 lb-in.

(b) Tighten nut to 2000 lb-in.

(c) Mark location of nut with reference to mating part.

(d) Turn nut through angle of 10 degrees minimum to 15 degrees maximum.

(e) Loosen nut to 0 lb-in. and repeat step (b).

(f) If mark on nut is in line with or beyond mating part reference mark within 0.050 inch maximum, apply final angle of turn per step (d).

(g) If marks are not within limits, repeat steps (c), (d), and (e) in order, until marks are within limits. Then perform step (f).

<u>NOTE</u>: If front accessory drivegear is of type retained by bearing inner race retaining nut lip (see step (17), below), check clearance between drivegear and No. 1 bearing inner race retaining nut with a 0.001 inch feeler gage. There must be no contact between gear and nut. If there is contact, disassemble and inspect parts.

(17) Secure inner race retaining nut with one of following procedures:

(a) Front accessory drivegear held by retaining nut lip; install rivet in nut from hub ID side through holes in drivegear and hub. Flare rivet with PWA 31743 Riveter.

(b) Front accessory drivegear held by snapring. Compress snapring (if used during torquing procedure) and remove drivegear from hub. Install rivet from hub ID side, through hole in hub. Flare rivet with PWA 31743 Riveter. Reinstall drivegear, lining up any hole in drivegear rim with rivet location in hub, and engage snapring behind retaining nut lip.

(18) Remove temporary bolts securing front and rear supports and install bearing housing and bearing outer race and rollers in front support, aligning indexing marks and boltholes. Install bolts. Tighten bolts to recommended torque and lockwire.

(19) Position two lubricated packings (larger one first) on longer section of "L" shaped oil suction tube. Install tube in opening at approximate eight o'clock position in No. 1 bearing front support. Position one lubricated packing on forward groove of oil suction tube.

(20) Make certain steel pin securing No. 1 bearing oil strainer assembly in oil strainer body is in place. Position a new packing on oil strainer body and install body and strainer assembly into No. 1 bearing oil transfer tube of front support.

(21) Secure body to No. 1 bearing housing with two bolts. Tighten bolts to recommended torque and lockwire.

(22) Place new packing over short tube between two boltholes of oil strainer body and install No. 1 bearing oil nozzle assembly on oil strainer body, long tube through hole in bearing housing. Install and tighten two bolts to recommended torque and lockwire.

NOTE: Prior to installation oil flow check nozzles in accordance with following procedure and Figure 410C.

(a) Lower two tubes and raise oil inlet adapter of PWA-16012 Fixture.

(b) Install new packing on oil strainer body. Position body to fixture and secure with bolts.

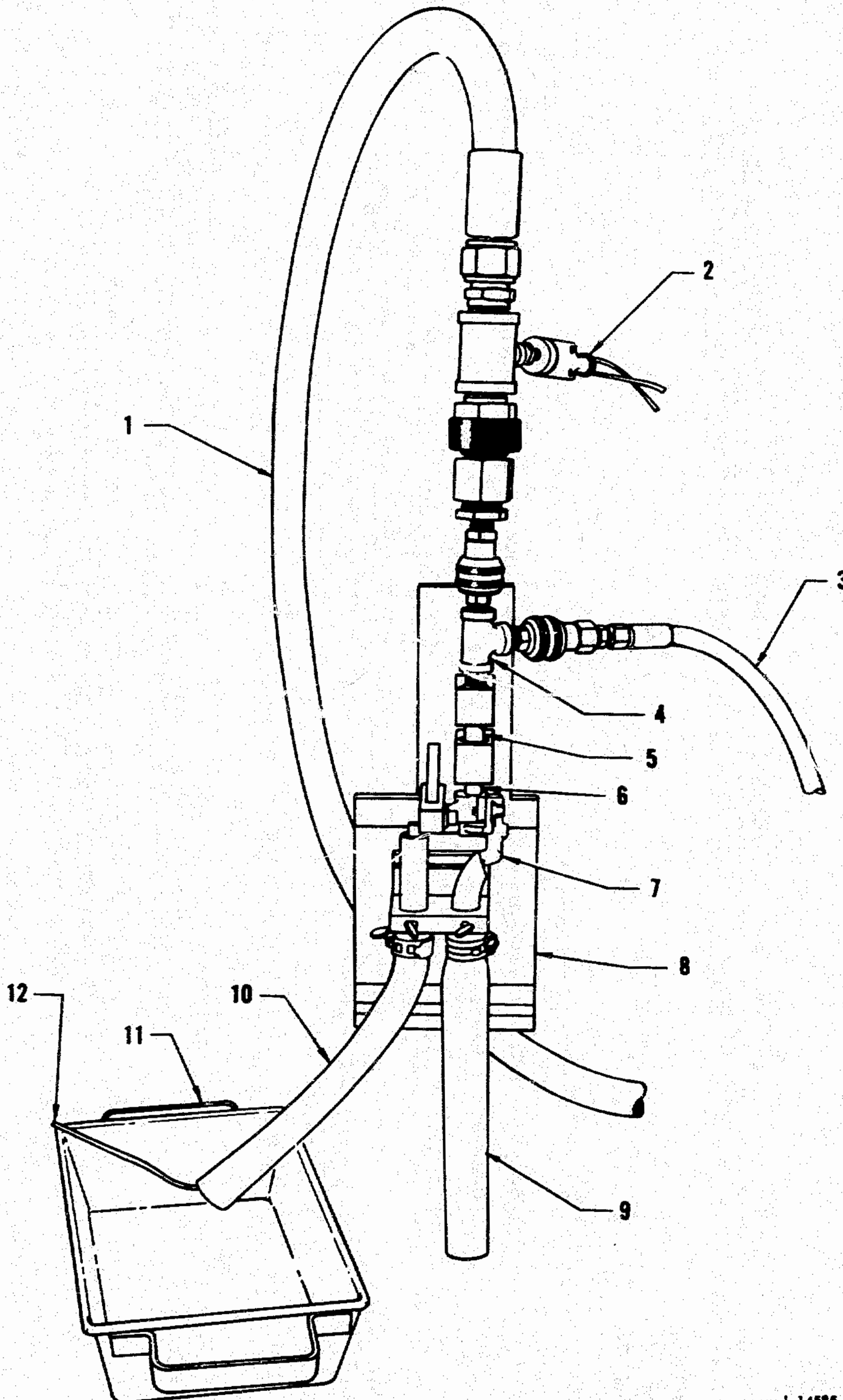
(c) Position No. 1 bearing oil nozzle assembly (jets pointing down) to body, installing new packing between parts, and secure with bolts.

(d) Position two oil tubes of fixture to nozzle jets and secure tubes.

(e) Install packing on each end of strainer element assembly and install strainer into boss of fixture to seat against installed body.

(f) Secure oil inlet adapter of fixture over strainer element assembly on transfer tube.

(g) Attach oil supply line from suitable test stand to inlet adapter of fixture. Regulate oil pressure at 40 psig ±1 psi.



No. 1 Bearing Oil Nozzle and Seal Jet
Oil Flow Check

Figure 410C

1. Oil in Hose
2. Oil in Temperature Thermocouple (Typical)
3. Oil Pressure Gage Connection
4. Oil Inlet Adapter
5. Strainer Element
6. Oil Strainer Body
7. Nozzle Assembly
8. PWA-16012 Fixture
9. No. 1 Bearing Jet Oil Flow
10. No. 1 Bearing Seal Jet Oil Flow
11. Oil Flow Container (Typical)
12. Oil Out Temperature Thermocouple (Typical)

Key to Figure 410C

(h) Weigh oil flow from No. 1 bearing jet. Oil flow must be 2.5 to 3.0 lb/min.

(j) Weight oil flow from No. 1 bearing seal jet. Oil flow must be 2.5 to 3.0 lb/min.

(k) Remove engine parts from fixture.

(23) Remove supports from fan discharge case.

NOTE: Paragraph 28L must be complied with following above procedure.

28L. Front Accessory Drive Support Assembly and No. 1 Bearing Section Air Pressure Check

A. Procedure

(1) Place a new seal in groove on rear face of assembled front accessory drive support.

(2) Align pin in front accessory drive support with hole in No. 1 bearing support, then bring front accessory drive support into position, making sure that scavenge pump and tachometer drivegears mesh properly with main accessory drivegear.

(3) Secure front accessory drive support to bearing support with washers and bolts. Tighten bolts to recommended torque and lockwire.

(4) Install PWA-10489 Connector to front compressor front bearing oil pressure fitting on compressor inlet case weldment.

(5) Connect air supply to connector.

(6) Regulate air supply to ten psi and check total airflow through flowmeter. Measured airflow must be within seven to twelve PPH.

(7) Disconnect air supply line and remove connector from No. 1 bearing pressure fitting.

NOTE: If this section is disassembled after airflow check, this air check must be repeated after assembly.

29. Removal/Installation of the Combustion Chambers

A. Removal

NOTE: All aircraft component tubing which interferes with this operation must be removed. Before removal of any part, mark the location of all clips and clamps to facilitate installation.

(1) With the engine in a horizontal position support it at the compressor intermediate case and the turbine exhaust case.

(2) Remove the high voltage leads from the sparkigniters; then remove the sparkigniters.

(3) Remove the exhaust temperature thermocouple lead, rear bearing pressure and scavenge oil lines and the combustion chamber drain line which extends rearward from the fireseal.

(4) Remove all brackets and clips at the front flange of the turbine nozzle case (rear flange of the combustion chamber outer rear case). Note their locations.

CAUTION: WITH THE COMBUSTION CHAMBER OUTER REAR CASE MOVED BACK, THE LOAD ABOUT THE TURBINE REAR MOUNT PLANE MUST NOT EXCEED 2650 INCH-POUNDS. THIS RESTRICTION IS NECESSARY TO PREVENT A LOAD ON THE ENGINE THAT COULD DAMAGE THE SEALS OR BEARINGS. THEREFORE, REMOVE THE AIRFRAME SILENCER AND REVERSER OR MAKE PROVISIONS TO ADEQUATELY SUPPORT THEM DURING THIS PHASE OF MAINTENANCE.

(5) Remove the flange bolts and nuts securing the combustion chamber outer rear case to the shorter combustion chamber outer front case.

(6) Remove the screws which attach the sections of the fireseal and remove these sections.

NOTE: This step may be omitted but removing the top sections of the fireseal permits a slightly larger work area.

(7) Position the PWA-16210 Collar around the approximate center of the combustion chamber outer rear case and secure with the swing bolt and nut.

(8) Using a chain hoist, attach the PWA-6580 Sling to the collar spools and take up the slack.

(9) Remove the nuts which attach the combustion chamber outer rear case to the turbine nozzle case front flange.

(10) Slide the combustion chamber outer rear case rearward over the turbine nozzle case as far as it will go.

(11) Temporarily secure the lower section of the fireseal to the combustion chamber outer front case rear flange using engine bolts and nuts.

(12) Number the combustion chambers, using layout dye, from one to eight (clockwise) starting with the top right hand chamber as viewed from the rear.

(13) Remove all the bolts securing the combustion chamber clamps. If clamp incorporates spacer between bolt flanges, devise some method of keeping spacer with same clamp, such as lockwiring spacer to clamp, to ensure reinstallation with same clamp.

(14) Slide the clamps forward on all of the even numbered chambers.

NOTE: The removal sequence steps (15) through (16) are for earlier configuration chambers. These combustion chambers with male crossover tubes (No. 2, 4, 6, and 8) must be disengaged first. No. 4 combustion chamber contains the opening for burner transfer tube, attached to right fuel manifold and must be removed directly rearward before lifting from fuel nozzles. On the newer Type III chambers, only the No. 5 chamber contains two male crossover tubes. The disengaging sequence with these chambers is No. 5, 6, 4, 3, 7, 2, 8, and 1. Disengage No. 4 chamber incorporating burner transfer tube directly rearward.

(15) Slide the even numbered (2, 4, 6, and 8) combustion chambers rearward moving the rear of the chamber outward to disengage the chamber lug from the positioning bracket, to clear the fuel nozzles; then rotate each chamber approximately ten degrees to disengege the cross-over tubes. (See Figure 411). Lower to rest on adjacent parts.

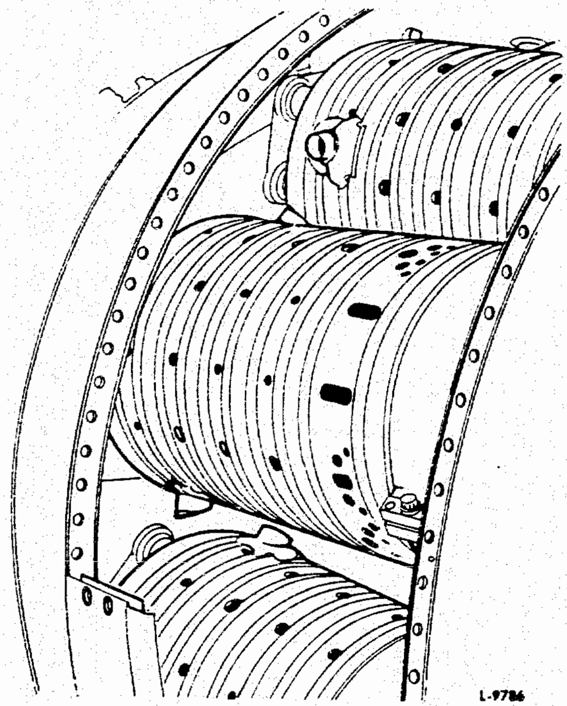
CAUTION: AVOID BENDING OR DAMAGING THE POSITIONING BRACKETS AND BURNER TRANSFER TUBE WHICH IS IN THE NO. 4 COMBUSTION CHAMBER. IF NECESSARY LOOSEN OR REMOVE THE POSITIONING BRACKETS.

(16) Starting at the bottom repeat step (15) with the odd numbered (5, 3, 7, 1) chambers.

CAUTION: AS THE ODD NUMBERED CHAMBERS ARE MOVED REARWARD AND ROTATED, THE CHAMBERS ABOVE ARE FREE AND MUST BE HELD TO PREVENT DAMAGE TO THE FUEL NOZZLES. WORK PROGRESSIVELY UPWARD FROM THE BOTTOM WHEN ROTATING THE CHAMBERS AND CAREFULLY SHIFT THEM DOWNWARD.

(17) After all the combustion chambers are shifted downward, sufficient space is achieved at the top to remove either the No. 1 or No. 8 chamber. (See Figure 412.)

(18) Select either one and lift it slightly and swing the rearward end outward so that the combustion chamber inside edge will clear through the opening in the outlet duct. See Figure 413. Continue to swing the rear of the chamber outward and remove it from the engine.



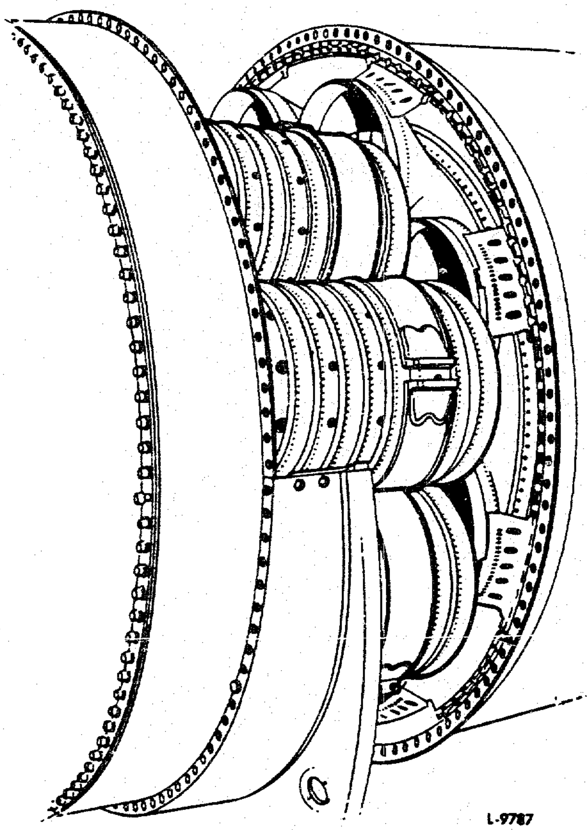
Preparing Combustion Chamber Liners for Removal
Figure 411

(19) Remove rest of combustion chambers in same manner. The lower chambers must be raised upward to a position above fireseal prior to removal.

(20) Install protective covers over fuel nozzle clusters.

(21) Inspect fuel manifold for loose heatshields. No looseness is allowed. If looseness is found, replace fuel manifold heatshield and all insulation material. Refer to Section 73-5-1, Fuel Manifold Repair of Accessory Component Overhaul Manual, PN 411569.

ENGINE - DISMANTLING/ASSEMBLY



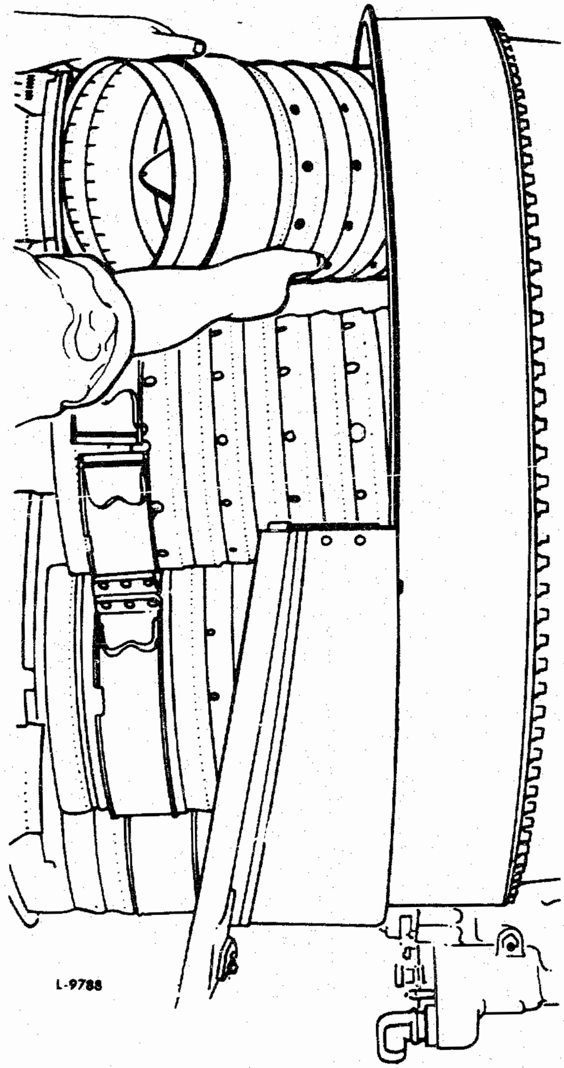
Combustion Chambers Positioned for Removal
Figure 412

B. Installation

(1) The following precautions must be observed during chamber and chamber clamp installation.

(a) Do not mix chamber types within an engine set. See Section 72-0, Inspection/Check, for part number and type identification. Install only Type III chambers in JT3D-3B engines and other models incorporating SB 609 (JT3D-1, D-3, MC-7) or SB 765 (JT3D-1-MC6). Install only Type II chambers in JT3D-1, D-3, MC-6, and MC-7 engines not incorporating these bulletins.

NOTE: Engines converted to smokeless burner configuration require use of new modified Type III combustion chambers and matching clamps that must only be used in this new configuration in complete sets even though old and new parts are physically interchangeable.



Removing Top Combustion Chamber
Figure 413

ENGINE - DISMANTLING/ASSEMBLY

(b) Chambers without hardfaced locating lugs are not acceptable for installation into engines.

(c) Chambers without hardfaced eleventh outer liners are not acceptable for installation into engines.

(d) Combustion chamber clamps which are not hardfaced in forward ID which mates with combustion chamber are not acceptable for installation into engines.

(e) Clamps, PN 622382, incorporating loose heatshield, PN 622379, installed (trapped) in center ID of clamp may not be operated without heatshield.

(f) Interchangeability of clamps within an engine set of eight is as follows: loose (trapped heatshield type clamps and welded-in heatshield type clamps can be used in complete engine sets respectively (preferred) or may be combined within an engine set if desired. Inter-mixing of Hastelloy and steel clamps of either heatshield design is also permissible. Combinations of heatshielded (all types) and non-heatshielded type clamps within an engine set are not recommended.

NOTE: Engines converted to smokeless burner configuration require use of new combustion chamber clamps that must only be used in this new configuration in complete sets even though old and new clamps are physically interchangeable.

(2) Measure combustion chamber eleventh liner and record average OD.

(3) Measure both front and rear ID of clamp and record average ID and for clamps incorporating spacer, the spacer thickness required.

(4) Using actual sizes of parts, as recorded on combustion chamber, outlet duct, and clamp, calculate fit which will result when parts are assembled. For each of eight combinations of chamber, outlet duct, and clamp, fit must be as follows.

(a) Hastelloy material clamps (loose heatshield): PN 622382 clamp (must have PN 622379 heatshield assembled in place in center ID).

Clamp Front ID	9.783 - 9.789
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.000 - 0.010L	
Clamp Rear ID	9.779 - 9.785
Outlet Duct Porthole OD	9.783 - 9.789
Fit 0.002L - 0.010T	
Clamp Center ID	9.898 - 9.902
Heatshield OD	9.902 - 9.908
Fit 0.000 - 0.010T	

(b) Hastelloy material clamps (welded-in heatshield): PN 488124 (SB 1771), change letter E or later; PN 500183 (SB 1771), change letter C or later; PN 622378; and PN 644546.

Clamp Front ID	9.783 - 9.789
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.000 - 0.010L	

Clamp Rear ID	9.779 - 9.785
Outlet Duct Porthole OD	9.783 - 9.789
Fit 0.002L - 0.010T	

(c) Hastelloy material clamps (non-heat shielded): PN 488124, Change Letter E or later; PN 500183, Change Letter C or later.

Clamp Front ID	9.778 - 9.784
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.005L - 0.005T	

Clamp Rear ID	9.779 - 9.785
Outlet Duct Porthole OD	9.783 - 9.789
Fit 0.002L - 0.010T	

(d) Steel material clamps (welded-in heat shield): PN 488124 (SB 1771), prior to Change Letter E; PN 500183 (SB 1771), prior to Change Letter C; and PN 647338.

Clamp Front ID	9.778 - 9.784
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.005L - 0.005T	

Clamp Rear ID	9.775 - 9.781
Outlet Duct Porthole OD	9.783 - 9.789
Fit 0.002T - 0.014T	

(e) Steel material clamps (non-heat shielded): PN 488124, prior to Change Letter E; PN 500183, prior to Change Letter C.

Clamp Front ID	9.773 - 9.779
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.000 - 0.010T	

Clamp Rear ID	9.775 - 9.781
Outlet Duct Porthole OD	9.783 - 9.789
Fit 0.002T - 0.014T	

ENGINE - DISMANTLING/ASSEMBLY

CAUTION: UNDER NO CIRCUMSTANCES IS AN ENGINE TO BE ASSEMBLED WITH EITHER CLAMP TO CHAMBER OR CLAMP TO PORTHOLE FIT OUTSIDE LIMITS.

(5) The most satisfactory condition is to mate chambers, clamps, and outlet duct portholes to achieve the mean of the fits limits at clamp to chamber and clamp to outlet duct porthole. However, clamp to chamber fit is more important than clamp to porthole fit.

(6) The desired fit may be achieved as follows.

(a) For welded-in heat shield and loose (trapped) heat shield type clamps, which use spacers between bolt flanges of clamp, select spacer of proper thickness from Table XII.

NOTE: Even though clamp may have been received with pre-selected spacer attached, it may be necessary to select a different spacer to obtain desired fit.

(b) For non-heatshielded type clamps, which do not use spacer, select chambers and clamps to make up an engine set which will meet fit requirements or rework clamp to welded-in heatshield type, with spacer.

Spacer, PN 622383, is provided in the following thicknesses:

CL 7	0.045 - 0.047	CL 13	0.027 - 0.029
CL 8	0.042 - 0.044	CL 14	0.024 - 0.026
CL 9	0.039 - 0.041	CL 15	0.021 - 0.023
CL 10	0.036 - 0.038	CL 16	0.018 - 0.020
CL 11	0.033 - 0.035	CL 17	0.015 - 0.017
CL 12	0.030 - 0.032		

TABLE XII

(7) When an engine set of chambers and clamps has been selected, mark chamber position on chamber, using non-permanent marking method, or some other system which will ensure that chamber/clamp combination will be installed in proper sequence, as follows:

Type II Chambers - 5-7-1-3-6-8-2-4
Type III Chambers - 1-8-2-7-3-4-6-5

(8) For loose (trapped) heatshield type clamps, select a heatshield which will give the desired clamp to heatshield fit. Mark position on heatshield, using non-permanent marking method. Do not install heatshield into clamp ID at this time.

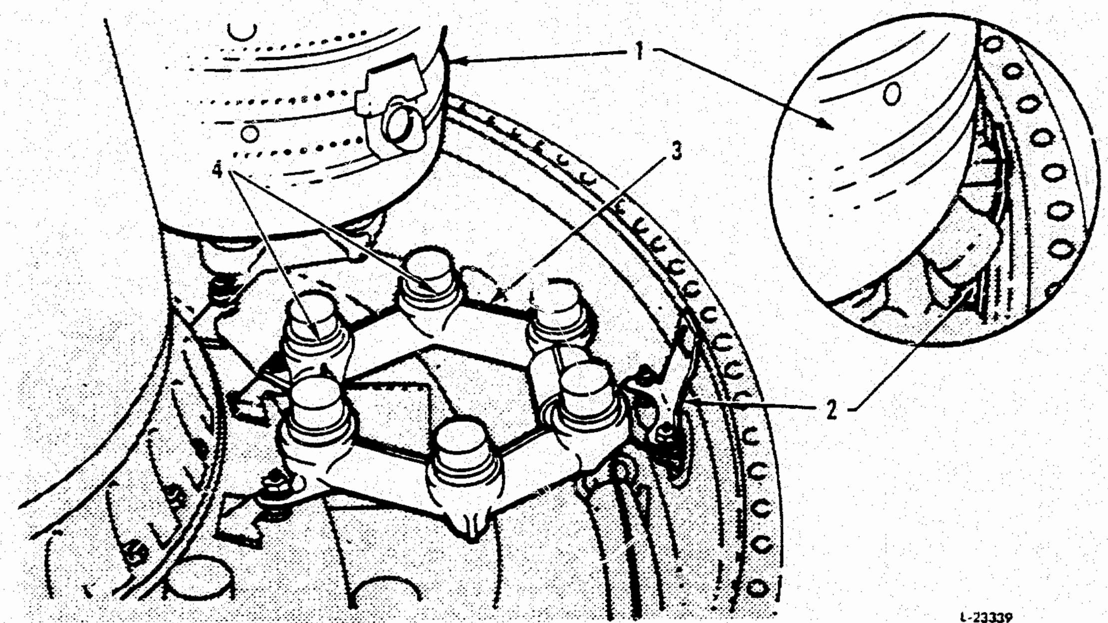
CAUTION: SPREAD CLAMP ONLY ENOUGH TO SLIP IT ONTO CHAMBER EXCESSIVE SPREADING WILL PERMANENTLY DEFORM CLAMP. FOR WELDED-IN HEATSHIELD TYPE CLAMPS, DO NOT ALLOW CLAMP TO SPRING OR SNAP CLOSED ON CHAMBER SINCE THIS WILL BEND HEATSHIELD AND CLOSE GAP BETWEEN HEATSHIELD AND CLAMP BODY.

(9) Spread ends of clamp and position clamp around chamber just forward of eleventh liner with split in clamp aligned axially with locating lug on chamber. Retain with clamp/chamber combination any circumferential shims and/or spacers which are associated with clamp. Do this for each of the eight clamp/chamber combinations in the engine set.

(10) Remove bolts securing combustion chamber outer front case to diffuser case. Move case back as far as it will go.

(11) For loose (trapped) heatshield type clamps, install heatshield into outlet duct porthole.

(12) With combustion chamber outer front case moved rearward and with chamber positioning bracket (installed on manifold OD mount studs) loosened, install first chamber in sequence to seat on fuel nozzle cluster with chamber lug in position to engage positioning bracket. See Figure 414.



Index No.	Dimensions and Notes
1.	Combustion Chamber.
2.	Combustion Chamber Positioning Bracket. Nuts Securing This Bracket Must Be Installed Loosely Enough to Permit Bracket To Lean Toward OD of Engine During Chamber Installation.
3.	Fuel Nozzle Cluster.
4.	Shoulder On Fuel Nozzle. Install Chamber So hat Swirl Guides Seat On These Shoulders.

Combustion Chamber Installation
Figure 414

ENGINE - DISMANTLING/ASSEMBLY

(13) While holding chamber seated against fuel nozzle cluster, spread ends of clamp only enough to permit slipping clamp toward outlet duct to engage around porthole.

NOTE: If circumferential shim is used in clamp rear ID to set fit, slide shim into place after clamp has been loosely engaged on outlet duct porthole.

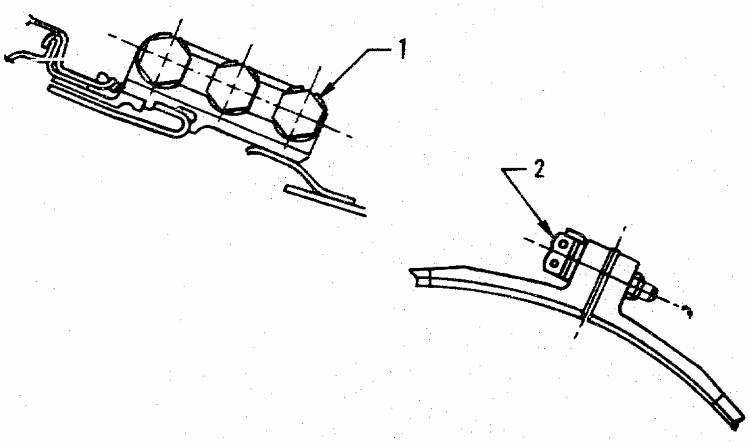
(14) For loose heatshield type clamps, move heatshield toward chamber and engage heatshield in clamp center ID as clamp is moved toward outlet duct porthole.

(15) Pull ends of clamp toward each other with finger pressure while inspecting to ensure that clamp is engaged 360 degrees around porthole and if circumferential shim is used, to ensure that shim is in place. Engage the notch at split in clamp over the anti-rotation lug on outlet duct porthole.

CAUTION: IF CLAMP HAS TWO NOTCHES, ENSURE THAT ONLY THE NOTCH AT SPLIT IN CLAMP IS USED.

(16) While holding ends of clamp as nearly together as possible, install tabwasher, three clamp bolts, and, if used, spacer between ends of clamp and run bolts down fingertight.

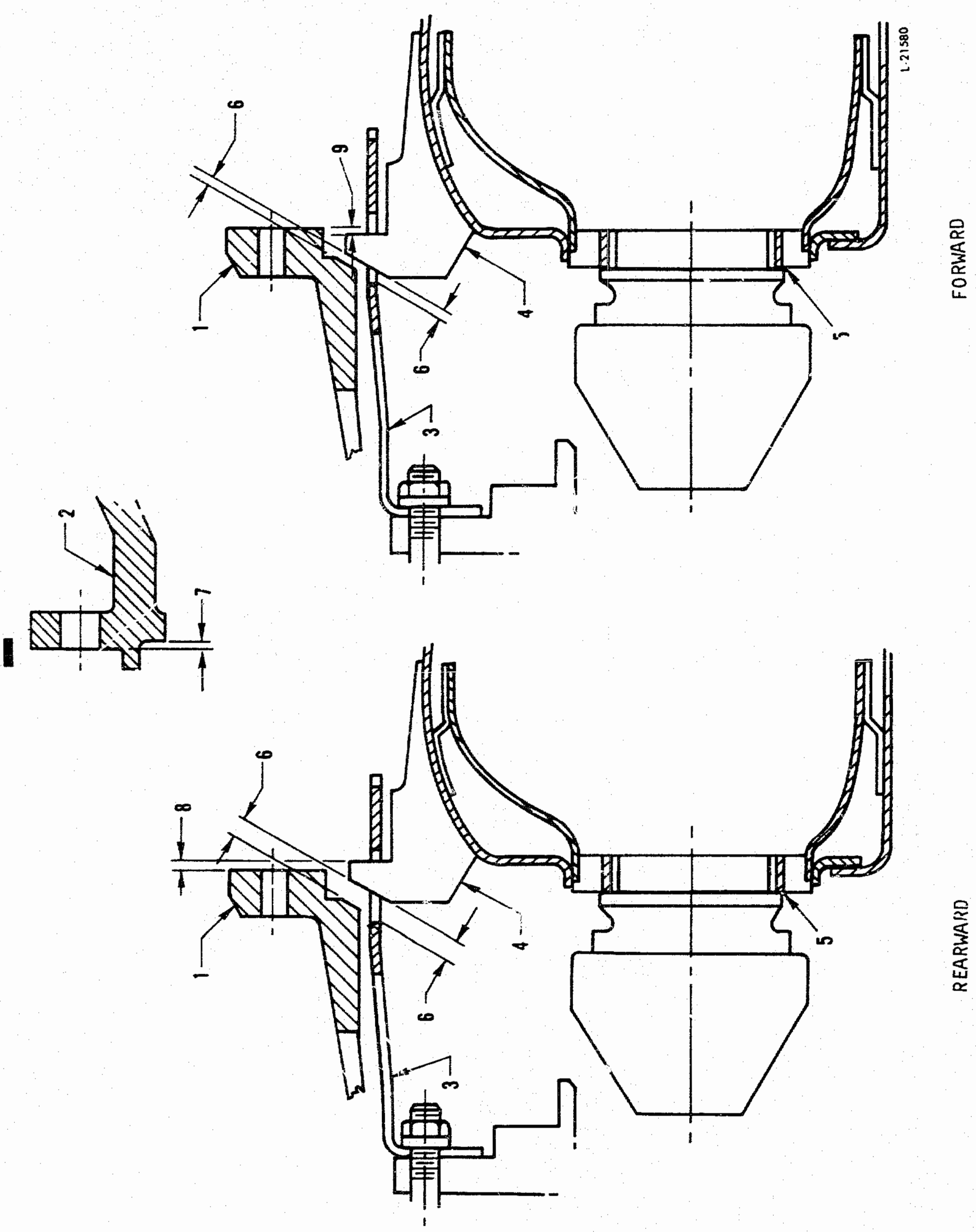
NOTE: See Figure 415 for clamp bolt arrangement. Do not use superseded type.



L-23173

Index No.	Dimensions and Notes
1.	Single Hexhead Bolt Keywasher.
2.	Single Hexhead Bolt.

Combustion Chamber Clamp Bolting Arrangement
Figure 415



Relation of Combustion Chamber
Locating Lug to Diffuser Case

Figure 416

1. Diffuser Case, Rear OD Flange

2. Combustion Chamber Outer Front Case, Front Flange

3. Combustion Chamber Positioning Bracket

4. Combustion Chamber Locating Lug

5. Zero Clearance Between Chamber Swirl Guide And Shoulder On Fuel Nozzle Body During This Check.

6. With Zero Clearance At Index No. 5, There Must Be Some Clearance Between Forward Angled Face Of Lug And Both Diffuser Case Flange And Positioning Bracket.

7. Depth Of Scallop In Front Flange Of Outer Front Case. Begin Reading Table XIII (Column I) At This Value.

8. Face Of Lug Rearward Of Diffuser Case Flange. Table XIII, Column III, Defines Maximum.

9. Face Of Lug Forward Of Diffuser Case Flange. Table XIII, Column II Defines Maximum.

Key to Figure 416

ENGINE - DISMANTLING/ASSEMBLY

CAUTION: CHECK FOR PROPER ENGAGEMENT OF CLAMP ALL AROUND (360 DEGREES) ON FLANGE OF COMBUSTION CHAMBER OUTLET DUCT PORTHOLE AS CLAMP BOLTS ARE TIGHTENED.

(17) Tighten clamp screws to recommended torque. Do not bend tabwasher at this time.

(18) With combustion chambers seated against their respective fuel nozzle clusters, check to determine that some clearance exists between foward face of chamber locating lug and both diffuser case and forward end of slot in chamber positioning bracket. See Figure 416, Index 6.

NOTE: If check does not indicate some clearance, it is probable that some major repair problem exists in manifold or diffuser case manifold mounting lugs, or chamber locating lug, which must be defined and necessary parts replaced before proceeding with engine assembly.

(19) With each combustion chamber seated against its fuel nozzle cluster, measure relationship between rear (hardfaced) face of chamber lug and rear face of diffuser case flange. See Figure 416. Check Table XIII to determine that actual measurement is within limits specified for outer front case scallop depth, as marked on OD of front outer case near scallop. If all parts involved (manifold, manifold mount lugs in diffuser case chamber locating lug, outer front case scallop) individually meet limits defined in Section 72-0, Inspection/Check, then this measurement should fall between Column II and Column III of Table XIII.

(20) Further tighten clamp bolts part of a turn as necessary to make possible bending tabwasher against a flat on bolthead. Bend tabwashers and lockwire bolts.

(21) Remove lower fireseal section from engine.

(22) Install sparkigniters.

(23) Position PWA 16210 Collar around combustion chamber rear outer case at approximate center and secure with swing bolt and nut; then attach PWA 6580 Sling to spools of collar.

(24) Coat snap diameter on underside of rear flange and mating flange of turbine case with molybdenum disulfide antiseize compound.

Combustion Chamber Outer Front Case - Scallop Depth	Acceptable Range - Chamber Lug Measurement Forward Index No. 9, Figure 416 (Maximum)	Rearward Index No. 8, Figure 416 (Replace If Under)
Column I	Column II	Column III
0.075	0.019	0.050
0.074	0.020	0.049
0.073	0.021	0.048
0.072	0.022	0.047
0.071	0.023	0.046
0.070	0.024	0.045
0.069	0.025	0.044
0.068	0.026	0.043
0.067	0.027	0.042
0.066	0.028	0.041
0.065	0.029	0.040
0.064	0.030	0.039
0.063	0.031	0.038
0.062	0.032	0.037
0.061	0.033	0.036
0.060	0.034	0.035
0.059	0.035	0.034
0.058	0.036	0.033
0.057	0.037	0.032
0.056	0.038	0.031
0.055	0.039	0.030

NOTE: Begin reading table at Column I (scallop depth). Read horizontally to find maximum forward and rearward measurements of lug face, relative to diffuser case flange.

TABLE XIII

(25) Move the combustion chamber case forward into position.

CAUTION: DO NOT BUMP THE CASE AGAINST THE COMBUSTION CHAMBER LINERS SINCE MISALIGNMENT WITH THE FUEL NOZZLES MAY OCCUR. BEFORE CLOSING THE GAP BETWEEN THE FLANGES, VISUALLY CHECK EACH LINER FOR PROPER POSITIONING AND ALIGNMENT.

(26) Align the bolt holes of the combustion chamber rear outer case rear flange with the gangbolts in the turbine nozzle case front flange; then continue to move the outer case forward, aligning the offset hole, until the front and rear flanges are joined.

(27) Reinstall the three sections of the fireseal and temporarily secure the sections to the mating front flanges with a few bolts and locknuts (boltheads to rear).

(28) Install the rear of the bolts and locknuts securing the combustion chamber outer rear case front flange to the shorter combustion chamber outer front case (bolthead to rear). Tighten the locknuts to the recommended torque.

(29) Install the two screws on each side securing the fireseal section. Tighten the screws to the recommended torque.

(30) Install the brackets and clips, noted at disassembly, to the front flange of the turbine nozzle case (rear flange of the combustion chamber outer rear case). Secure the mating flanges, clips and brackets with the locknuts. Tighten the locknuts to the recommended torque.

(31) Reinstall the combustion chamber drain line, rear bearing pressure and scavenge oil lines and the exhaust temperature thermocouple lead.

(32) Using the chain hoist and sling loosen the collar swing bolt and nut and remove the collar.

(33) Connect the sparkigniter leads and the exhaust thermocouple lead. Replace all external parts to the locations from which they were removed.

30. Removal/Installation of First Stage Nozzle Guide Vanes

See Figure 417.

A. Removal

CAUTION: TURBINE NOZZLE CASE IS SUPPORTED BY FIRST STAGE TURBINE NOZZLE GUIDE VANES. MAKE CERTAIN NOZZLE CASE IS ADEQUATELY SUPPORTED IF SIZABLE QUANTITY OF VANES ARE TO BE REMOVED. THIS MAY BE ACCOMPLISHED BY REPOSITIONING COMBUSTION CHAMBER OUTER FRONT CASE (ONLY) TO DIFFUSER CASE REAR FLANGE AND SECURING IT WITH SUFFICIENT BOLTS. INSTALL FOUR PWA 17205 SUPPORTS, 90 DEGREES APART, BETWEEN COMBUSTION CHAMBER OUTER FRONT CASE AND TURBINE NOZZLE CASE, OR POSITION SADDLE ARRANGEMENT TO LOWER NECKED-DOWN SECTION OF TURBINE NOZZLE CASE. MAKE CERTAIN AIRFRAME SILENCER AND REVERSER ARE REMOVED OR ADEQUATELY SUPPORTED DURING THIS PHASE OF MAINTENANCE.

NOTE: Remove combustion chambers per Section 72-0, Paragraph 29.

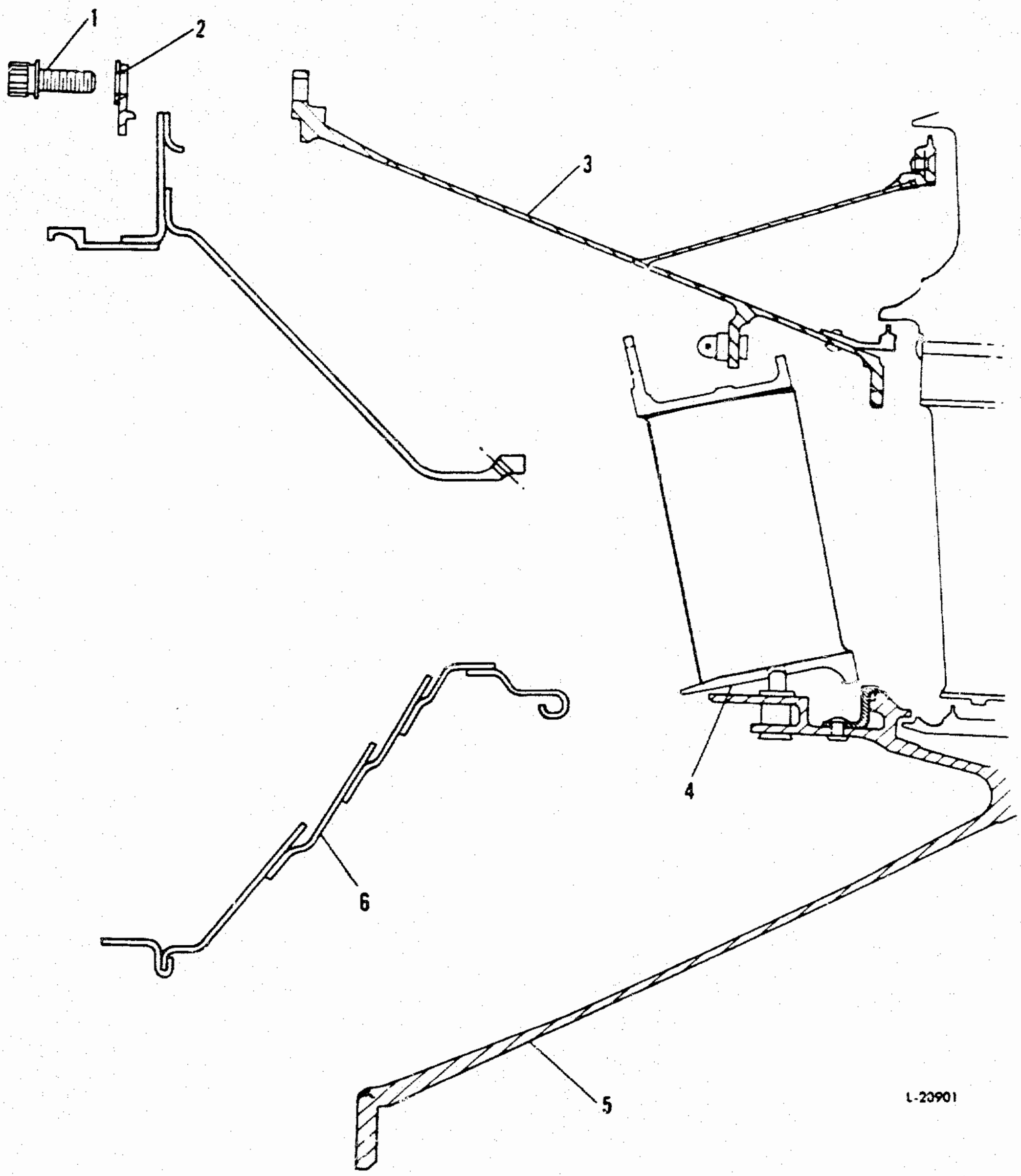
(1) Remove bolts; then remove clamp plates securing outlet duct to turbine nozzle inner case. Remove clamp plates.

(2) Mark one of the fingers in outlet duct and its position in gangbolt assembly in nozzle case; then remove Allen screws securing eight gangbolt assemblies, spacers, and outlet duct to nozzle case front flange. Remove gangbolt assemblies while supporting outlet duct.

NOTE: Mark gangbolt assemblies to assure their reinstallation in proper location at assembly.

(3) Pull outlet duct forward to expose first stage nozzle vanes.

(4) Using an approved method, number vanes and their location in order to assure their return to same location.



1. Retaining Nut
2. Outlet Duct Clamp Plate
3. Turbine Nozzle Inner Case
4. Turbine Vane
5. Turbine Nozzle Outer Case
6. Combustion Chamber Outlet Duct

First Stage Nozzle Guide Vane Removal

Figure 417

(5) Remove the lockwire from a vane retaining pin, and using a rocking motion, pull the vane forward from its seat. Remove as many vanes as required in this manner.

NOTE: When it is necessary to remove all the vanes, 12 or more vanes should be left in (evenly dispersed) until after a sufficient number of new vanes are installed to prevent cocking of the turbine case. The number of vanes, up to 100 percent, may be replaced in a nozzle assembly as long as each replacement vane is the same class as the vane which it replaces. If replacement by exact class is not possible, the new average class should be determined to be within limits by recalculation.

B. Installation

(1) Insert the vanes into their seats and snap them into position aligning the vane retaining pins with their holes in the vanes. Lockwire the retaining pins in pairs, except, lockwire last three vanes together. See Figure 418.

NOTE: Make certain correct numbered vane or replacement (if required) is returned to its original position.

Engines incorporating turbine stator support assembly, P/N 622402 or 625948, must use vanes, P/N 536751. These vanes are installed with bolts, P/N 523514. Torque bolts and then lockwire as described in step (1).

(2) Position the outlet duct assembly to the turbine nozzle inner case and the turbine nozzle case front flange in the location marked at disassembly.

(3) Install a reinforcing plate between each outlet duct flange and turbine case front flange and an outlet duct positioning plate against front face of each flange so that each outlet duct flange is located between reinforcing plate and positioning plate.

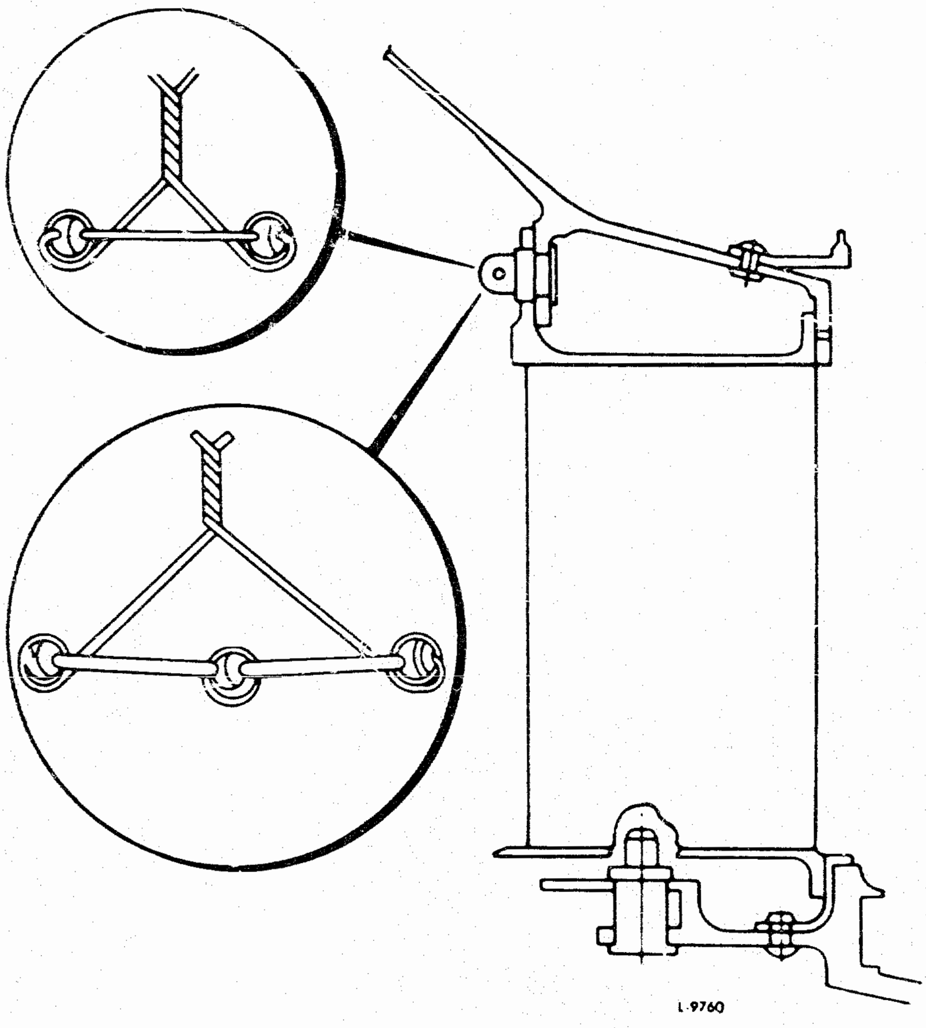
NOTE: Hardfaced outlet duct flanges should be assembled between hardfaced reinforcing and positioning plates, (scuff plates) but may be assembled between non-hardfaced plates.

CAUTION: DO NOT ASSEMBLE NON-HARDFACED OUTLET DUCT FLANGES BETWEEN HARDFACED REINFORCING AND POSITIONING PLATES.

(4) Position the seven-bolt gangbolts to retain the reinforcing and positioning plates and the flanges of combustion chamber outlet duct against the turbine nozzle case front flange. Secure gangbolts to nozzle case flange with socket head screws.

(5) Install the outlet duct clamp plates and insert the bolts securing them to the turbine nozzle inner case. Tighten the bolts to the recommended torque.

NOTE: The combustion chambers and combustion chamber outer cases shall be reinstalled as outlined in Paragraph 29. B.



First Stage Turbine Vanes Lockwiring

Figure 418

31. Numerical Tool List

PWA 2536 Puller

PWA 3095 Guide

PWA 3687 Puller

PWA 3755 Pump

PWA 3790-50 Puller

PWA 6580 Sling

PWA 6676 Drift

PWA 6841 Drift

PWA 7143 Drift

PWA 7146 Puller

PWA 7153 Fixture

PWA 7337 Drift

PWA 8050 Wrench
(Superseded by PWA 18872)

PWA 8192 Spacer

PWA 8193 Puller

PWA 8663 Saddle

PWA 8664 Adapter

PWA 8665 Adapter

PWA 8740 Adapter

PWA 9156-51 Protector

PWA 9156-52 Protector

PWA 10381 Drift

PWA 10489 Connector

PWA 10631 Base

PWA 10859 Sling

PWA 10860 Stand

PWA 10903 Support

PWA 13030 Guide

PWA 14047 Guide

PWA 16012 Fixture

PWA 16031 Wrench

PWA 16039 Spacer

PWA 16040 Wrench

PWA 16041 Wrench

PWA 16042 Riveter
(Superseded by PWA 31743)

PWA 16043 Puller

PWA 16044 Compressor

PWA 16050 Puller

PWA 16157 Puller

PWA 16158 Drift

PWA 16161 Base

PWA 16162 Drift

PWA 16177 Support

PWA 16210 Collar

PWA 16220 Adapter

PWA 16249 Holder

ENGINE - DISMANTLING/ASSEMBLY

PWA 16281 Puller

PWA 16282 Teeth

PWA 16295 Base

PWA 16337 Drift

PWA 16338 Puller

PWA 16358 Drift

PWA 16359 Puller

PWA 16366 Guide

PWA 16367 Drift

PWA 16375 Mount

PWA 16453 Drift

PWA 16454 Base

PWA 16455 Drift

PWA 16460 Guide

PWA 16463 Puller

PWA 16514 Stand

PWA 16566 Bracket

PWA 16567 Bracket

PWA 16572 Teeth

PWA 16768 Drift

PWA 16930 Guide

PWA 16935 Support

PWA 17078 Drift

PWA 17205 Support

PWA 17412 Puller

PWA 18872 Wrench
(Supersedes PWA 8050)

PWA 20333 Adapter

PWA 20334 Plate

PWA 30016 Drift

PWA 30017 Base

PWA 30343 Base

PWA 30344 Drift

PWA 30429 Base

PWA 30430 Drift

PWA 30643 Puller

PWA 31469 Riveter
(Superseded by PWA 31743)

PWA 31743
(Supersedes by PWA 16042, 31469)

ENGINE - ADJUSTMENT/TEST

1. Engine Test

A. General

(1) This section contains the procedures and limits for ground testing installed engines after repair. When trimming the engine or making a thrust check in conjunction with these test, the applicable airframe manufacturers curves, corrected for installation losses, must be used.

NOTE: The test procedure as given in this section are the same for all models unless otherwise specified. Test curves are indicated for specific engine models.

B. Engine Ground Safety Precautions

(1) General

(a) The operating characteristics of jet engine powered aircraft have changed the ground safety picture. To prevent injury to persons and damage to property, handling and working procedures must be modified to meet new exposures. On piston engine aircraft the propeller was carefully avoided. In the case of the jet engine powered aircraft, not only must one avoid the engine intake ducts, but also the exhaust nozzle where hot, high velocity exhaust gases are discharged. These gases are discharged forward, rather than rearward, when the reverse thrust mechanism is actuated. For turbofan engines, the fan discharge area must also be avoided as the velocity of the discharged air, particularly at high thrust settings, is sufficiently high to cause serious injury.

(b) Listed below are some of the general safety items which shall be supplemented according to the needs of the job, to prevent accidents.

(2) The Air Intake

See Figure 501.

WARNING: THE ENGINE IS CAPABLE OF DEVELOPING ENOUGH SUCTION AT THE INLET DUCT TO PULL A MAN UP TO IT OR PARTIALLY INTO IT WITH POSSIBLE FATAL RESULTS. IT FOLLOWS THAT WHEN A APPROACHING ANY TYPE OF JET ENGINE, PRECAUTIONS MUST BE TAKEN TO KEEP CLEAR OF THE INTAKE AIR STREAM. THE SUCTION NEAR THE INTAKE CAN ALSO PULL IN HATS, GLASSES, LOOSE CLOTHING AND WIPE-RAGS FROM POCKETS. ANY LOOSE ARTICLES MUST BE MADE SECURE OR REMOVED BEFORE WORKING AROUND THE ENGINE.

(3) Exhaust Characteristics

See Figure 501.

(a) Velocity. At high engine speeds the engine and fan exhaust may pick up and blow loose dirt, sizeable rocks, sand and debris a distance of several hundred feet. Therefore, due caution must be used in parking the aircraft for runup to avoid injury to persons or damage to property or other aircraft. A blast fence is suggested if the engines are going to be run up for trim and power adjustment in an area where there is not sufficient space available for dissipation of the exhaust blast. During reverser operation the fan exhaust air and engine exhaust gases are discharged in a forward direction. The velocity of their discharge is sufficient to take a person off his feet resulting in possible injury.

WARNING: PRIOR TO GROUND OPERATION OF THE THRUST REVERSER, ENSURE THAT AREA FORWARD OF ENGINE IS CLEAR AND WILL REMAIN CLEAR OF PERSONNEL.

(b) Temperature. High temperature will be found up to several hundred feet from the exhaust nozzle depending on wind conditions. Closer to the engine the temperature is high enough to deteriorate bituminous pavement, therefore concrete aprons are suggested for run-up areas. Occasionally when a jet engine is started, excess fuel that has accumulated in the tail pipe ignites and long flames are blown out of the exhaust nozzle. The possibility of this hazard must be watched and all flammable materials kept in the clear.

(c) Toxicity. Tests have indicated that the carbon monoxide content is low but other gases are present which have a disagreeable odor and are irritating in effect. Exposure will usually cause watering or a burning sensation of the eyes. Less noticeable but important is the respiratory irritation which may be caused. For both these reasons exposure must be avoided, particularly in confined spaces or pockets where the concentration may build up.

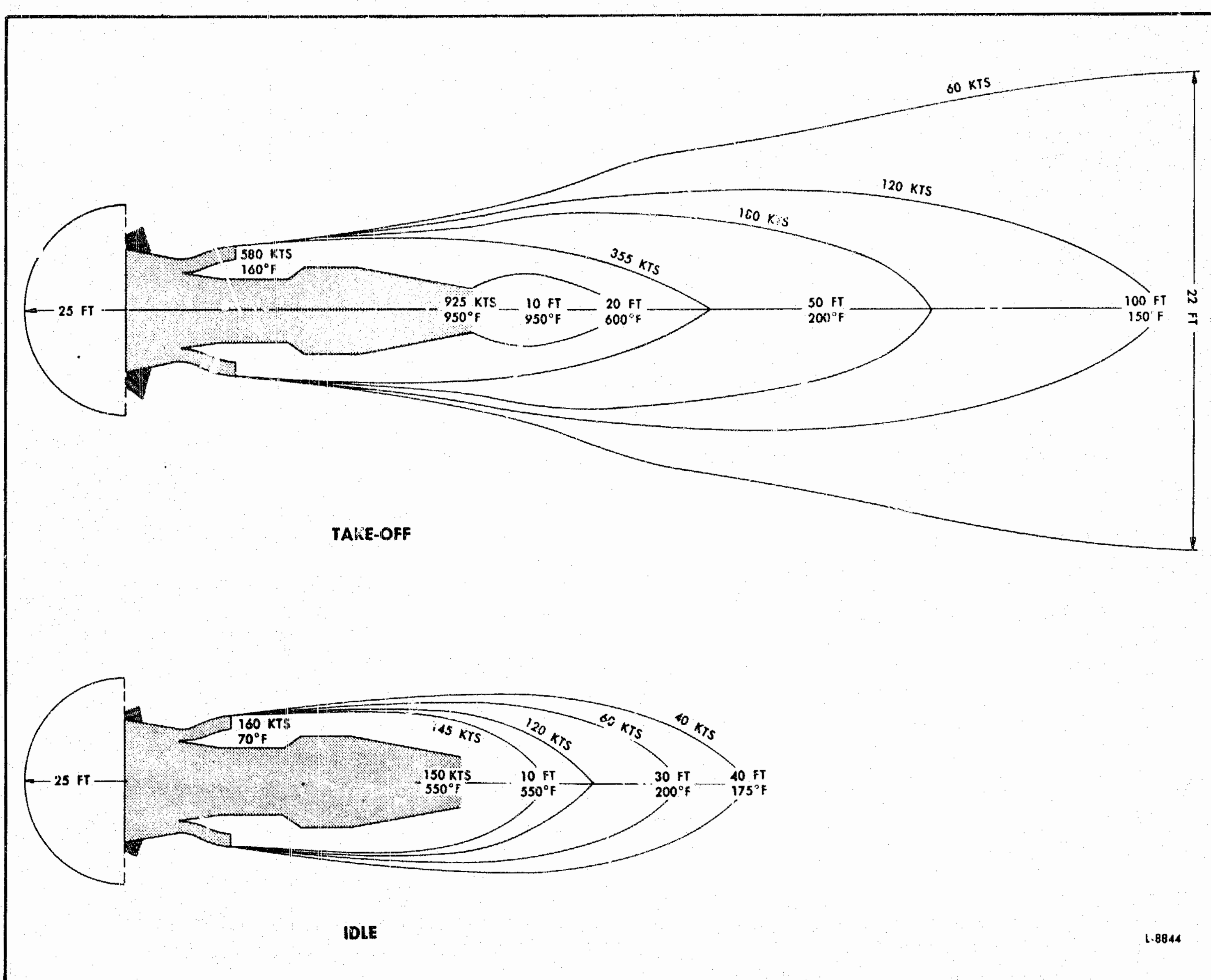
(4) Engine Cool Down. After engine operation no work or inspection shall be done on the tailpipe for one-half hour (preferably longer). All other parts may usually be worked on without danger.

ENGINE - ADJUSTMENT/TEST

(5) Compressor Bleed Valve

(a) When checking the bleed valve operation or doing other work in, or adjacent to, the compressor bleed valve while the engine is running, care shall be taken to stand clear during bleed valve open operation.

WARNING: WHEN THE BLEED VALVE OPENS, HIGH PRESSURE AIR AT HIGH VELOCITY IS DUMPED OVERBOARD. EXPERIENCE HAS PROVEN THAT THE FORCE OF THIS AIR, PARTICULARLY WHEN THE VALVE FIRST OPENS DURING DECELERATION FROM HIGH RPM, IS SUFFICIENT TO TAKE A PERSON OFF HIS FEET RESULTING IN POSSIBLE INJURY.



Turbofan Engine Hazard Areas

Figure 501

(6) Engine Noise

(a) Jet engines produce noise capable of causing temporary, as well as permanent, loss of hearing. Even short exposures to extreme noise may result in damage to the ears and all personnel must use some means of protection. Therefore, the use of cup type ear protection is recommended. Noise can effect the ear mechanism in such a way as to cause unsteadiness or inability to walk or stand without reeling. If engines are to be serviced from aero-stands or platforms, these shall be equipped with protective railings to prevent falls.

(7) Engine Ignition

WARNING: THE JT3D ENGINE IGNITION SYSTEM IS CHARACTERISTICALLY HIGH IN ENERGY. THE NATURE OF THE SYSTEM IS SUCH AS TO RENDER IT A HAZARDOUS, POSSIBLY FATAL, SOURCE OF ELECTRICAL SHOCK UNLESS THE NECESSARY PRECAUTIONS ARE EXERCISED.

(8) Fuel and Lubricating Oils

(a) All fuels have a desiccating effect which drys the skin. Precautions shall be taken to avoid contact as much as possible.

C. General Testing Information

(1) Because the thrust developed by the engine is indicated by the difference in pressure or the pressure ratio (which is also proportional to engine thrust) between the engine air inlet and the discharge pressure at the jet nozzle, turbine discharge pressure by itself shall not be used directly as an accurate indication of engine output. Compressor inlet pressure must also be taken into consideration on the curves used whenever turbine discharge pressure alone is instrumented on the engine. Compressor inlet pressure will be the true barometric pressure.

(2) When using turbine discharge pressure or engine pressure ratio to check or trim the engine, a turbine discharge pressure or pressure ratio overshoot, or higher than normal reading, may be noted when the power lever is first advanced to the PART THRUST stop on a cold engine. This overshoot will be followed by a gradual drop in turbine discharge pressure until a stabilized point is reached and the turbine discharge pressure will remain constant. This overshoot will be noted in the turbine discharge pressure gage but not on the tachometer, as the speed is governed and does not tend to overshoot. This overshoot is a normal condition on a cold engine and shall not be construed in any manner as engine malfunction. For an accurate indication of engine thrust during engine test or trimming, the engine must be allowed to stabilize.

ENGINE - ADJUSTMENT/TEST

(3) Symbols have been designated for the various stations within the engine and the external working pressures and temperatures. These variables are listed below:

Amb	- Ambient Temperature (T) or Pressure (P)
T_{amb}	- Compressor Ambient Temperature
N_1	- Low Pressure Compressor
N_2	- High Pressure Compressor
T_{t7}	- Turbine Discharge Total Temperature
P_{t7}	- Turbine Discharge Total Pressure
P_{t7}/P_{amb}	- Engine Pressure Ratio
T.B.	- True Barometer (Inches Hg Absolute)

(4) Accuracy of the instrumentation used for test shall conform to the following:

Ambient Temperatures (T_{amb})	±2°F
Ambient Pressure (P_{amb})	±0.01 in. Hg.
Turbine Discharge Pressure (P_{t7})	±0.10 in. Hg.
Turbine Discharge Temperature (T_{t7})	±5°F
Fuel Flow (W_f)	±1%
High Compressor (N_2) Speed	±0.1%
Low Compressor Discharge Pressure (P_{s3})	±0.25%

(5) The extent of repair and replacement will vary with each engine. Therefore, the degree of test necessary to demonstrate satisfactory repair will vary also. To minimize ground running and to conserve fuel, this section provides five ground test procedures which are related to the extent of repair or replacement. Before attempting to test an engine after repair, the applicable sections of the "Test Reference Table" must be consulted to determine the test required for any given engine repair.

(6) The Engine Check Table provides the general operating condition limits and references to the necessary test curves for testing an installed engine. The ratings listed in the Engine Check Table are described as follows:

(a) WET TAKE-OFF. This is the maximum thrust available for TAKE-OFF. The rating is obtained by actuating the water injection system and setting the computed P_{t7} or P_{t7}/P_{amb} ratio.

CAUTION: WATER MAY BE USED DOWN TO A TEMPERATURE OF 20°F (-6.7°C) IF PROVISION IS MADE TO HEAT THE WATER SUFFICIENTLY TO KEEP IT FROM FREEZING.

ENGINE - ADJUSTMENT/TEST

(b) DRY TAKE-OFF. This is maximum thrust available without use of water injection. The rating is obtained by positioning power lever to obtain computed DRY TAKE-OFF P_{t7} or P_{t7}/P_{amb} ratio for existing ambient conditions.

(c) MAXIMUM CONTINUOUS (NORMAL RATED). MAXIMUM CONTINUOUS AND NORMAL RATED thrust are same. This maximum thrust that may be used continuously. The rating is obtained by adjusting power lever to obtain P_{t7} or P_{t7}/P_{amb} determined for ambient conditions.

(d) MAXIMUM CRUISE. This is maximum thrust approved for cruising.

(e) IDLE. This is not an engine rating but, rather, a power lever position suitable for minimum thrust operation on ground or in flight. It is obtained by positioning power lever in IDLE detent.

(f) REVERSE. Reverse thrust will be obtained at power lever positions below IDLE.

D. Repair Test Reference Table

UNITS REPAIRED OR REPLACED	MINIMUM THRUST REQUIRED FOR GROUND CHECK RUN
Oil System	
Tubing, Oil Tank (If Supplied), Oil Filter, Pressure and Scavenge Pumps, Accessory Gearbox Seals (When Neither Gearbox Nor Fuel System Were Removed), Temperature Regulating Valve	Test A 104°F (40°C) Minimum Oil Temperature Recommended
Pressure Regulating Valve	Test A Permissible To Adjust Oil Pressure To 39-41 PSIG At Idle. 104°F (40°C) Minimum Oil Temperature Recommended.
Accessory Gearbox	Test B
Fuel System	
Low Pressure: Pump and Heater Filters, Fuel Heater, Tubing (Low Pressure)	Test A
High Pressure: Fuel Control and Fuel Pressurizing and Dump Valve Filters, Fuel Pressurizing and Dump Valve, Tubing, (High Pressure) Fuel Pump, Fuel Nozzles, Fuel Manifold, Fuel-Oil Cooler	Test C

Repair Test Reference Table (continued)

UNITS REPAIRED OR REPLACED	MINIMUM THRUST REQUIRED FOR GROUND CHECK RUN
Fuel Control	Test D
Hot Section	
Combustion Chambers, Outlet Duct, Nozzle Guide Vanes	Test B
Electrically Actuated Valves	
Anti-Icing Valve, Fuel De-Icing Valve	Visual
Bleed Control System	
Control Valve, Tubing	Test E
Ignition	
Spark Igniters, Exciter Units, Leads	Aural Check or Perform Start
Instrumentation	
PT7 Probes and Tubing	Leak Check System with Shop Air
EGT Probes and Harness	Check With Portable Temperature Calibration Equipment

ENGINE - ADJUSTMENT/TEST

E. Engine Operating Conditions and Limits

(1) Engine Check Table (JT3D-1,-1A,-1-MC6,-1A-MC6,-1-MC7,-1A-MC7)

GROUND OPERATING LIMITS						
OPERATING CONDITION	TIME Limit (Minutes)	Max. Observed EGT °F (°C) JT3D-1, -1-MC6, -1-MC7	JT3D-1A, -1A-MC6, -1A-MC7	Max. EGT Spread °F (°C)	Oil Press. Range PSIG Normal (6) (7)	Oil Temperature Range °F (°C)(9)
Wet Take-Off (1)	2 1/2	986 (530)	---	---	40 - 60	104-195(40-90)
Dry Take-Off	5 (2)	986 (530)	968 (520)	200°F (111.1°C)	40 - 60	104-195(40-90)
Maximum Continuous	Continuous	860 (460)	842 (450)	---	40 - 60	104-195(40-90) (8)
Maximum Cruise and below	Continuous	833 (445)	815 (435)	---	40 - 60	104-195(40-90)
Part Power Trim	Continuous	See Figure 505 (3)	See Figure 505 (3)	180°F (100°C)	40 - 60	104-195(40-90)
Idle	Continuous	644 (340) (4)	644 (340) (4)	---	35 Minimum	104-270(40-132) (10)
Starting	Not over 15 seconds	842 (450) (5)	842 (450) (5)	---	----	----
Acceleration	---	986 (530)	968 (520)	---	40 - 60	104-195(40-90)

Maximum Allowable Operating Speeds: 6800 rpm (N_1) and 10,200 rpm (N_2)

ENGINE - ADJUSTMENT/TEST

(2) Engine Check Table (JT3D-3,-3B,-3C)

GROUND OPERATING LIMITS						
OPERATING CONDITION	TIME Limit (Minutes)	Max. Observed EGT °F (°C) JT3D-3 JT3D-3B	JT3D-3C	Max. EGT Spread	Oil Press. Range PSIG Normal (6) (7)	Oil Temperature Range °F (°C)(9)
Wet Take-Off (1)	2 1/2	1031 (555)	----	---	40 - 60	104-195(40-90)
Dry Take-Off	5 (2)	1031 (555)	1013 (545)	200°F (111.1°C)	40 - 60	104-195(40-90)
Maximum Continuous	Continuous	914 (490)	896 (480)	---	40 - 60	104-195(40-90) (8)
Maximum Cruise and Below	Continuous	914 (490)	896 (480)	---	40 - 60	104-195(40-90)
Part Power Trim	Continuous	See Figure 506 (3)	See Figure 506 (3)	180°F (100°C)	40 - 60	104-195(40-90)
Idle	Continuous	644 (340) (4)	644 (340) (4)	---	35 Minimum	104-270(40-132) (10)
Starting	Not over 15 seconds	842 (450) (5)	842 (450) (5)	---	----	-----
Acceleration	---	1031 (555)	1013 (545)	---	40 - 60	104-195(40-90)

Maximum Allowable Operating Speed: 6800 (N_1) and 10250 (N_2)-JT3D-3
6850 (N_1) and 10300 (N_2)-JT3D-3B,-3C

NOTES: (1) Operation with water is limited to ambient temperatures above 20°F (-6.7°C). Water may be used between 20° and 40°F (-6.7° and 4.4°C) only if provisions are made to heat water sufficiently to keep it from freezing.

(2) If dry take-off thrust is used following wet take-off, total time during which take-off thrust may be used is limited to five minutes; time limit to commence when throttle was first advanced for wet take-off.

(3) This curve is not a limit. It is given as a guide to indicate the Tt7 which, if exceeded, may signify an engine malfunction.

(4) This is reference temperature which if exceeded would indicate an abnormal engine operating condition. Further operation of an engine exhibiting this condition should be at discretion of operator.

(5) Time limit applies to this temperature.

(6) Oil pressure gage should be vented to scavenge compartment.

(7) Normal oil pressure is 40-60 psig. At throttle settings of 62 percent N2 rpm (approximately 6,000 rpm) and above, oil pressures between 35 and 40 psig are undesirable. Oil pressures below normal shall be corrected. Formerly established 40-55 psig range may be retained for use if desired. If 40-55 psig range is used, aircraft instrumentation and documentation may contain only these values for the normal range.

(8) Normal engine oil-in temperatures for stabilized running at max continuous is shown in Figure 501A for engines with and without thermostatic bypass valves.

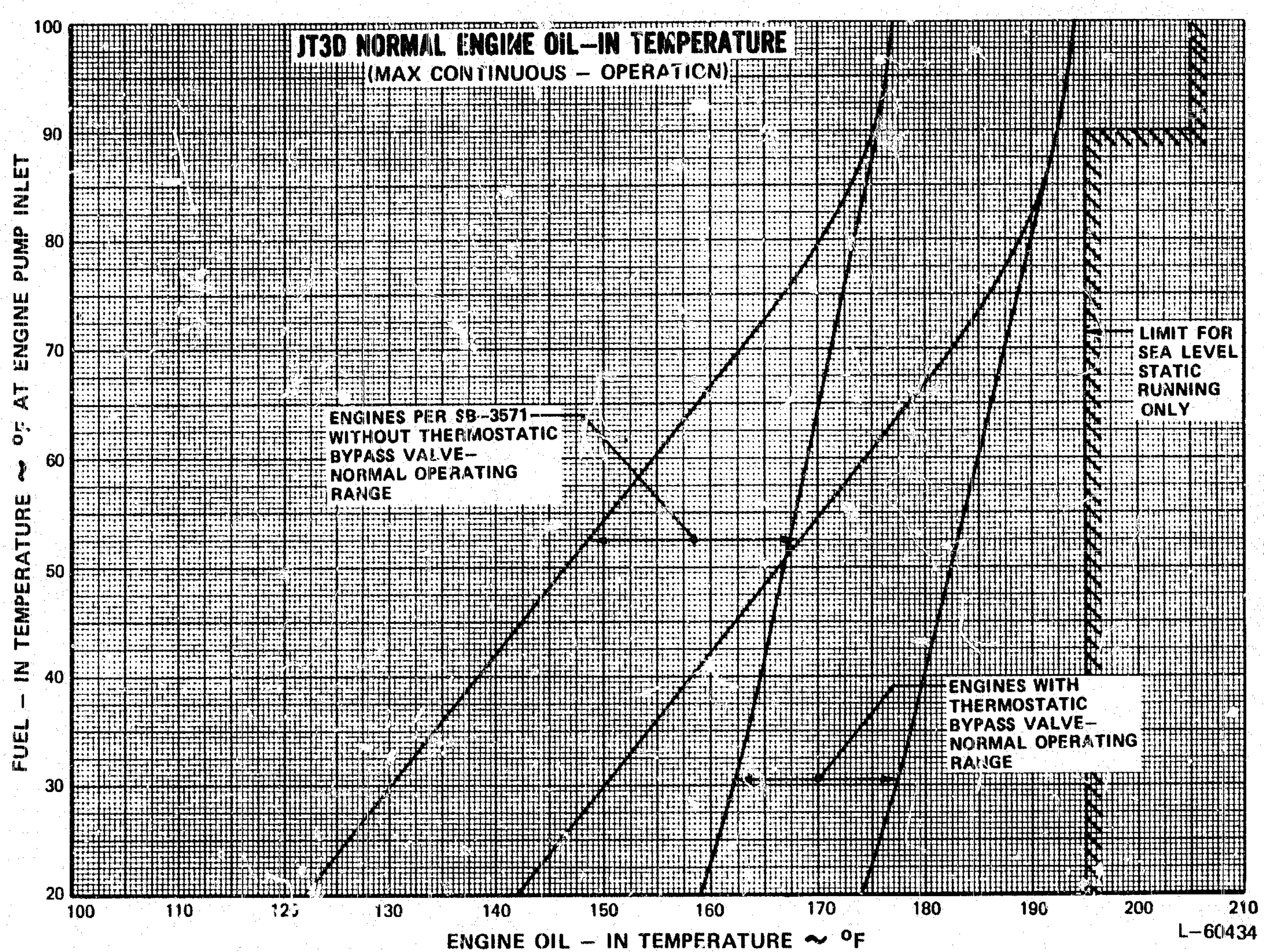
(9) If fuel inlet temperature reaches 90°F (37°C) or more, maximum oil temperature is 205°F (96°C).

(10) During transient deceleration oil-in temperature of 270°F (132°C) is allowable.

(3) Fuel Drainage

(a) A total drainage of up to 6.5cc per minute is permitted from the fuel system during operation on the acceptance test. Several of the components may develop leakages higher than their respective bench test figures in service. However, the sum of the acceptable service drain figures shall not exceed 6.5cc per minute. Drains must not be restricted by static pressure or line size.

(b) Maximum Expected Drainage - Engine Fuel Drains.



Normal Engine Oil-In Temperature
Figure 501A

Component	During Operation	Following Shut Down
Fuel Manifold (See Note 1)		43 oz.
Drain (Fuel Pressurizing and Dump Valve)	6cc/min. (See Note 2)	
Combustion Chamber		3 oz.
Fuel Control	1 1/2cc/min. (See Note 3)	
Fuel Pump	1 1/2cc/min.	

Note 1. Pressurizing and dump valve will drain 3 oz. on a start. On a false start, this 3 oz. plus normal shutdown drainage will occur.
Note 2. Component bench test drainage is 4cc/min. for this unit.
Note 3. If desired, the fuel pump and fuel control leakage may be checked collectively. Collective leakage shall not exceed 1 1/2 cc per minute. If the collective leakage limit is exceeded, the leakage shall be rechecked individually.

(4) Test Curves

(a) Pressure Ratio Bleed Control Limits - Figures 502, 503, 503A, 504, and 504A.

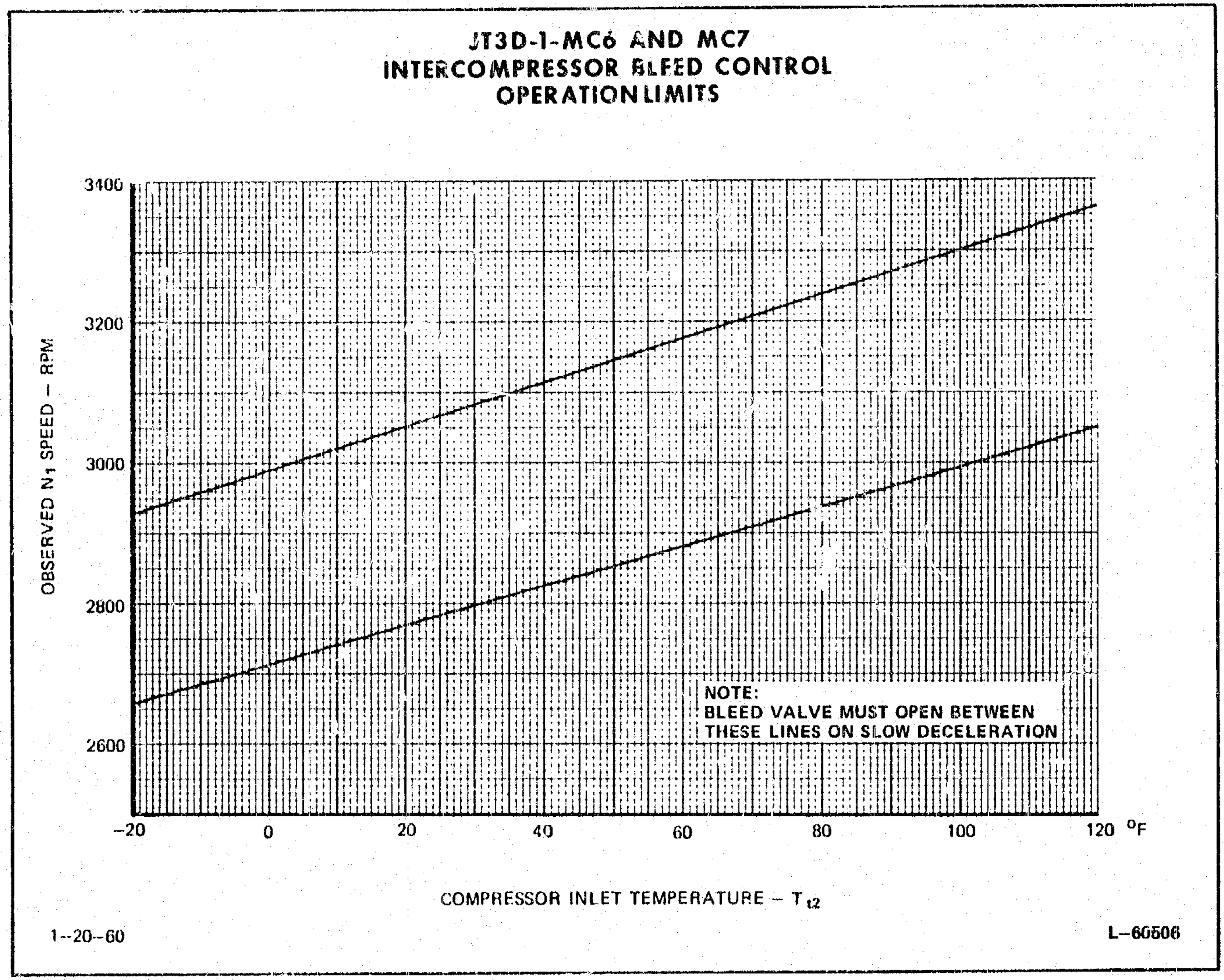
NOTE: See Table I for Bleed Valve And Actuator Assembly-to-Curve Identification.

(b) Maximum observed EGT at Part Power Trim Stop for JT3D-1, -1A,-1-MC6, -1A-MC6, -1-MC7, -1A-MC7 Engines - Figure 505.
(c) Maximum Observed EGT at Part Power Time Stop for JT3D-3,-3B,-3C Engines - Figure 506.

*BLEED VALVE AND ACTUATOR ASSEMBLY	BLEED CURVE FIGURE NO.	*BLEED VALVE AND ACTUATOR ASSEMBLY	BLEED CURVE FIGURE NO.
421601 SB 1123	504	564021	503
428214 SB 1123	503, 503A	755623	503
432976 SB 1123	503, 503A	783215	503A
448590 SB 1123	504	783216	503A
452457 SB 1123	503, 503A	783217	503A
453939 SB 1123	503, 503A	783218	503A
453942 SB 1123	504	783219	503A
454803 SB 1123	504	783210	504A
454805 SB 1123	503, 503A	783211	504A
454811 SB 1549	503, 503A	783212	504A
456423 SB 1123	503, 503A	783213	504A
464240 SB 1123	503, 503A	783214	504A
548991	503	783215	504A
560339	504	783216	504A
563879	504	783217	504A
563881	503	783218	504A
563883	504	783219	504A

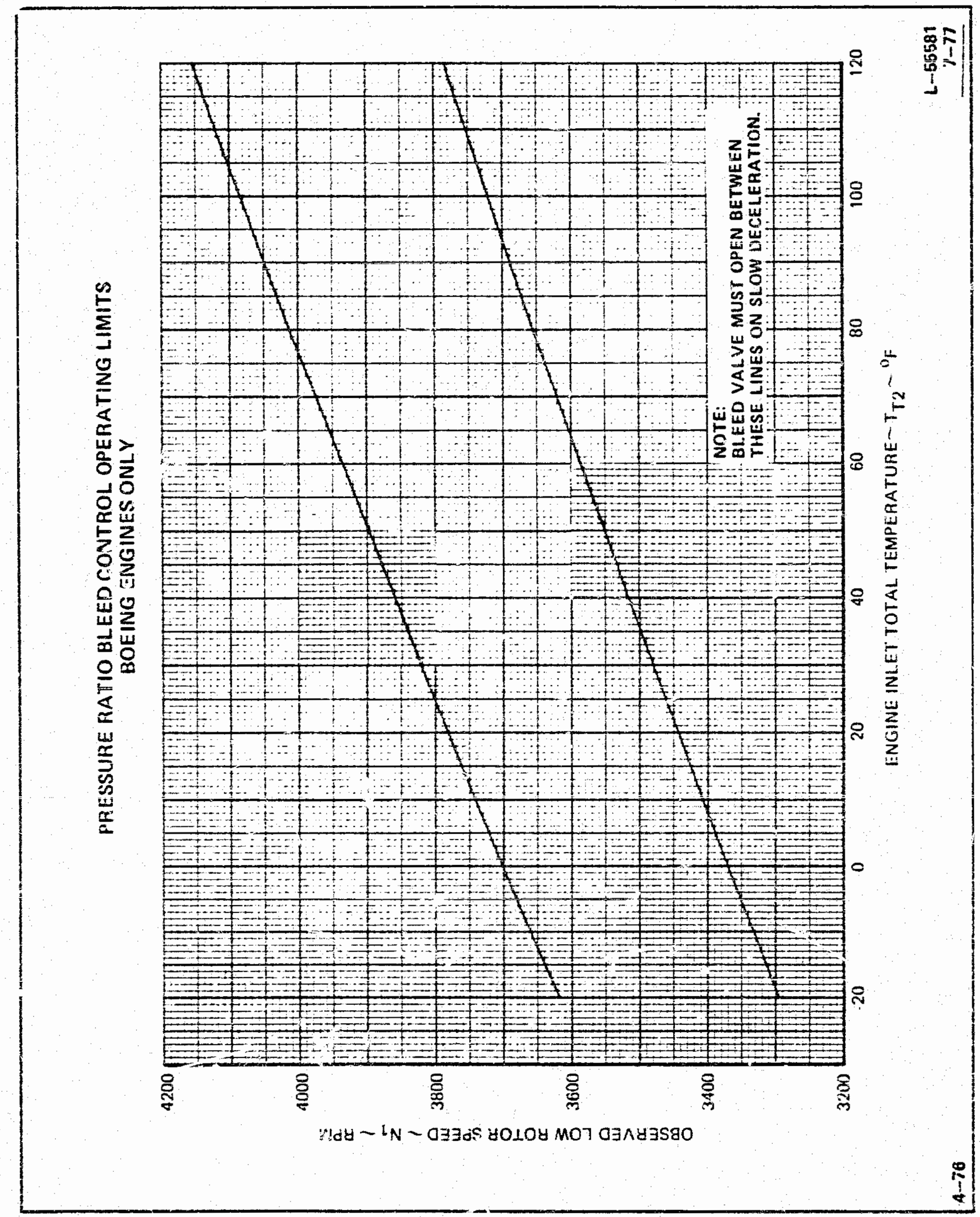
*Part Numbers are not listed for JT3D-1-MC6,-1A-MC6,-1-MC7,-1A-MC7 engines using Holley Bleed Controls. Figure 502 applies to these engines.

Bleed Valve And Actuator Assembly Part Number
With Bleed Curve Figure Number
Table I



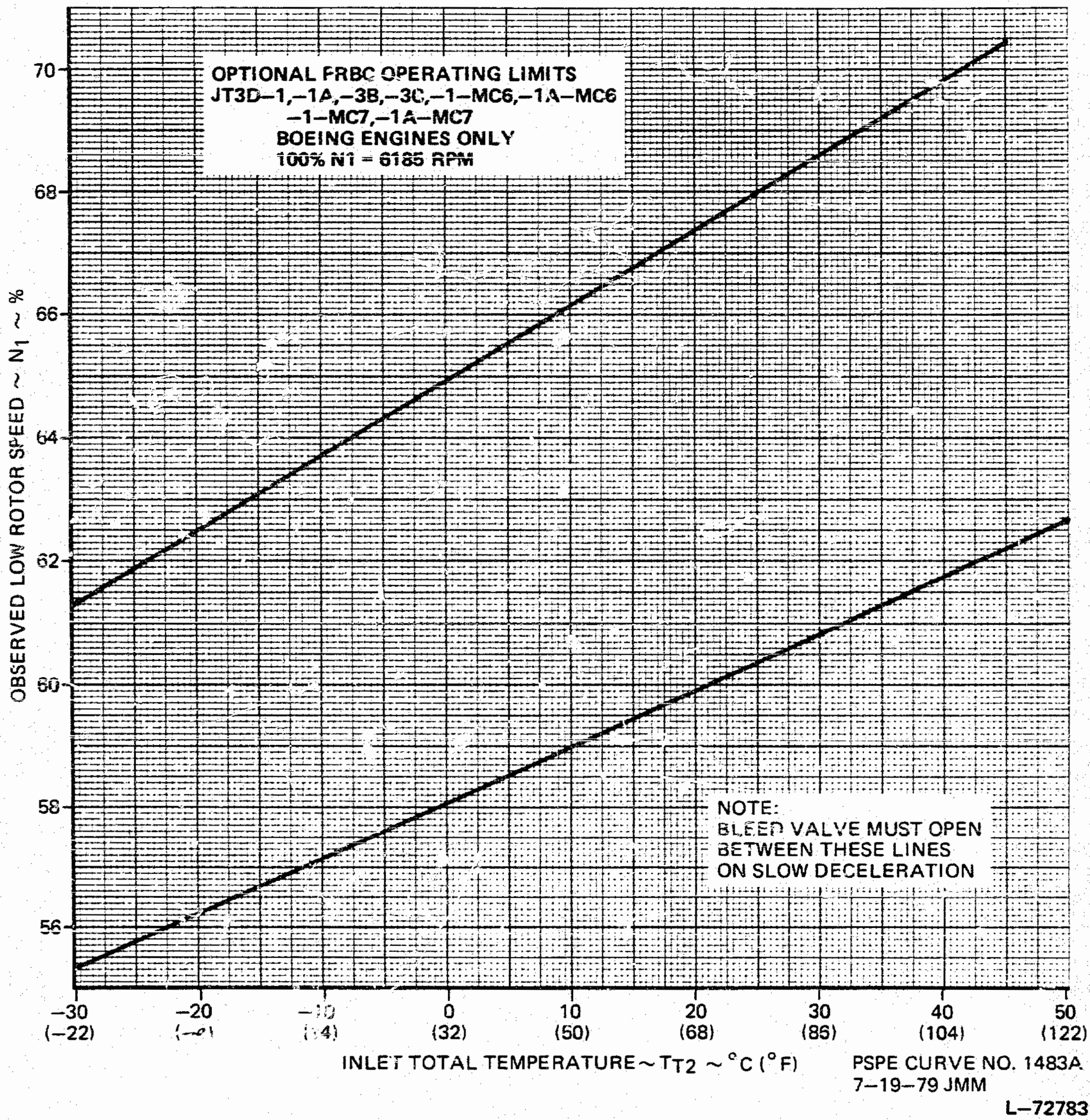
Intercompressor Bleed Control Limits
(JT3D-1-MC6 Boeing and JT3D-1-MC7)
Figure 502

ENGINE - ADJUSTMENT TEST



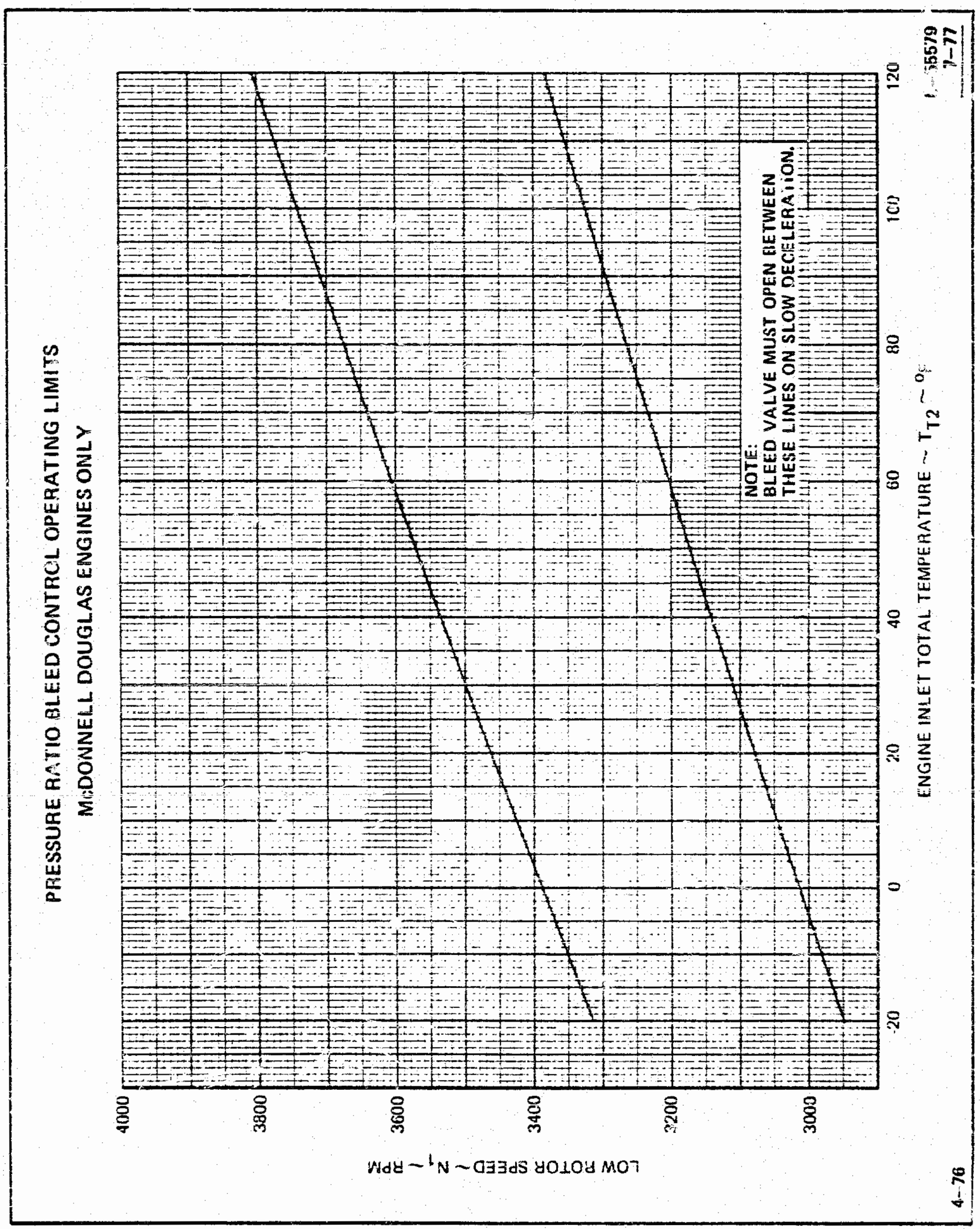
Pressure Ratio Bleed Control Operating
Limits (JT3D-1, D-3, D-3B, MC-7
and MC-6 Boeing Engines)
Figure 503

ENGINE - ADJUSTMENT/TEST



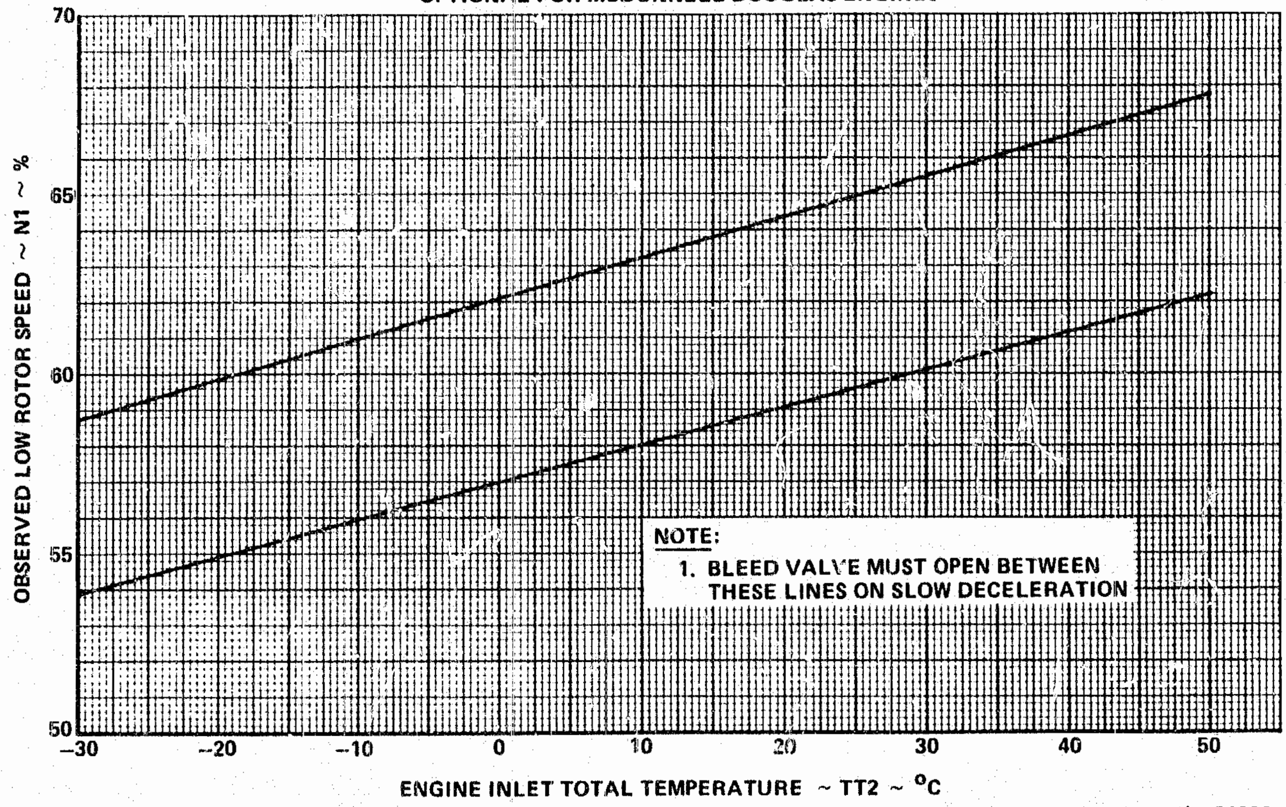
Optional Pressure Ratio Bleed Control
Operating Limits (JT3D-1,-3,-3B Boeing)
Figure 503A

ENGINE - ADJUSTMENT TEST



Pressure Ratio Bleed Control Operating
Limits (JT3D-1, D-3, D-3B,
Douglas Engines)
Figure 504

JT3D–1, –3, –3B TURBOFAN
PRESSURE RATIO BLEED CONTROL OPERATING LIMITS
OPTIONAL FOR MCDONNELL DOUGLAS ENGINES

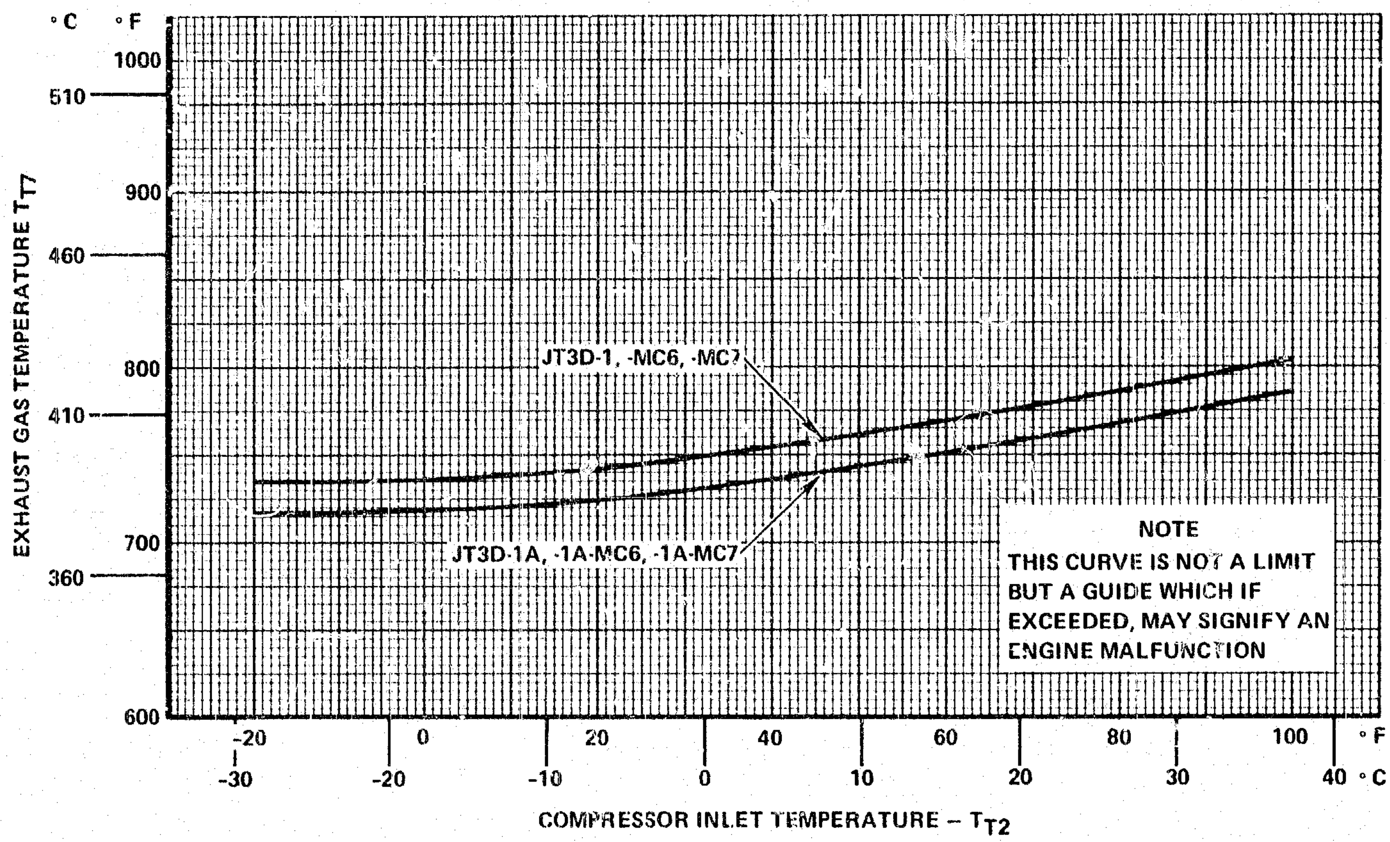


3–25–82

L–84296

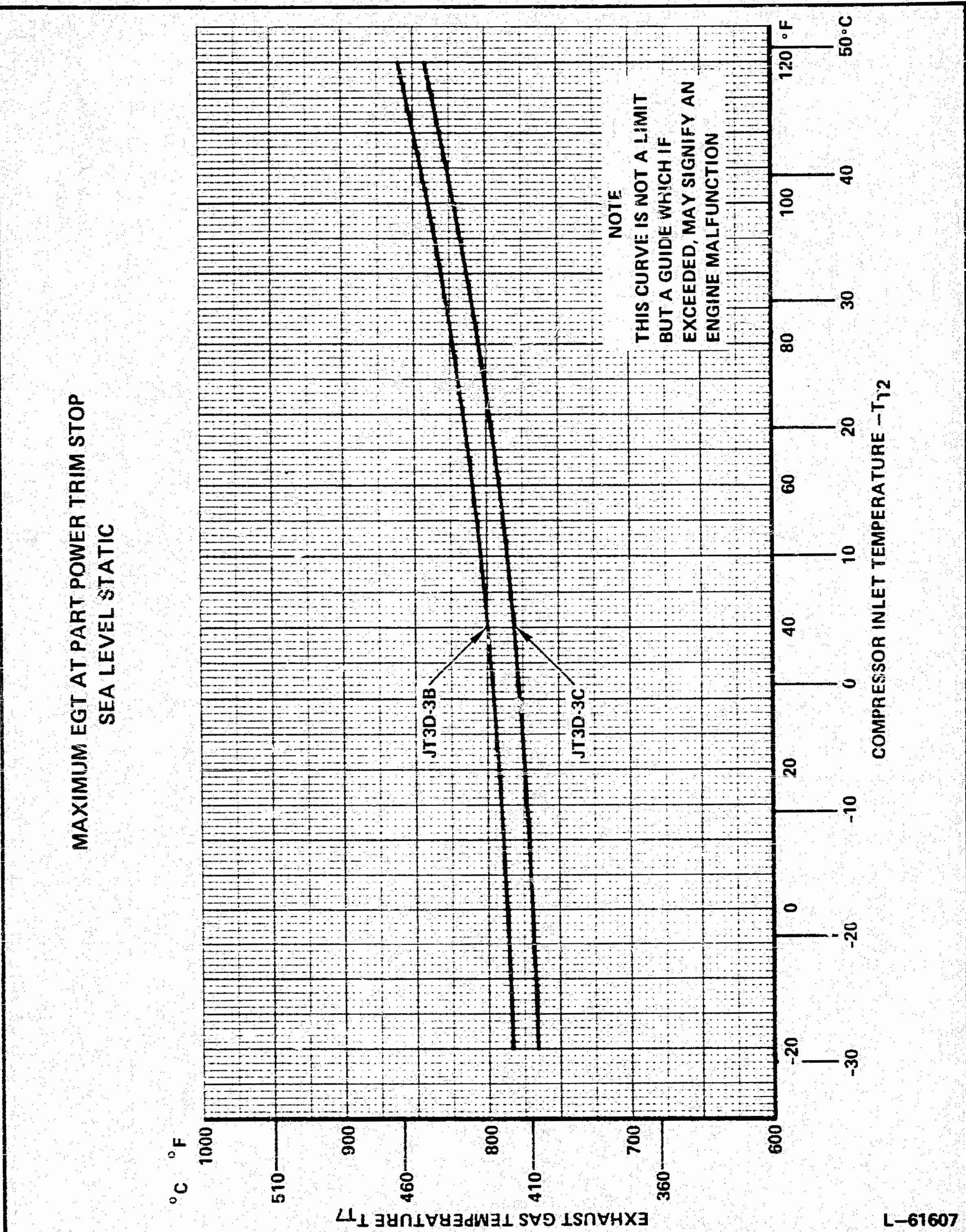
Pressure Ratio Bleed Control
Operating Limits
Figure 504A

MAXIMUM EGT AT PART POWER TRIM STOP
SEA LEVEL STATIC



L-62289

JT3D-1,-1A,-1-MC6,-1A-MC6,
-1-MC7,-1A-MC7 Maximum EGT
At Part Power Trim Stop
Figure 505



JT3D-3,-3B,-3C Maximum Observed
EGT At Part Power Trim Stop
Figure 506

ENGINE - ADJUSTMENT/TEST

F. Pre-Starting Inspection Prior To Test

(1) Fuel System

(a) Visually check all fuel system tubes and components for security and leakage.

(b) Remove, clean and install fuel pump filters.

(c) Remove, clean and install fuel control filters.

(d) Check fuel system for presence of water.

(e) Service fuel system with an approved fuel conforming to Specification PWA 522.

NOTE: Engine must be ground tested and trimmed using same grade fuel as used for flight operations. Slight variations for any given power lever position will result if alternate fuels are used.

(2) Oil System

(a) Remove, disassemble, clean, and reinstall main oil strainer.

(b) Visually check all oil system tubes and components for security and leakage.

(c) Fill oil tank with approved oil conforming to Specification PWA 521 synthetic oil.

CAUTION: UP TO TWO GALLONS OF OIL MAY BE IN SCAVENGE SECTIONS; THEREFORE, OIL MUST NOT BE ADDED TO TANK UNTIL SCAVENGE SECTIONS ARE CLEARED. IF PROCEDURE BELOW IS NOT FOLLOWED, EXCESSIVE OIL MAY BE ADDED WHICH WILL RESULT IN BUILD-UP OF SUFFICIENT INTERNAL PRESSURE TO RUPTURE TANK DURING ENGINE OPERATION.

(d) If oil is required after starting engine, engine shall be operated for approximately one minute at IDLE speed. This is required to make certain that any oil which may be in scavenge section of engine is returned to tank, thereby assuring accurate oil level check.

(3) Electrical System.

(a) Check the ignition system components for security.

CAUTION: INSUFFICIENT TORQUE ON HIGH TENSION LEAD NUT AT EXCITER AND IGNITER END CAN CAUSE IGNITION RADIATED NOISE TO BE PICKED UP BY AIRCRAFT RADIO EQUIPMENT.

(b) Remove both sparkigniters; check and reinstall.

WARNING: BECAUSE THE VOLTAGE TO THE SPARKIGNITERS IS DANGEROUSLY HIGH, THE IGNITION SWITCH MUST BE IN THE "OFF" POSITION BEFORE REMOVAL OF ANY OF THE IGNITION SYSTEM COMPONENTS. APPROXIMATELY THREE MINUTES OF TIME MUST ELAPSE BETWEEN THE OPERATION OF THE IGNITION SYSTEM AND THE REMOVAL OF COMPONENTS. WHEN A SPARK-IGNITER LEAD IS DETACHED FROM A SPARKIGNITER, TOUCH THE END OF THE LEAD TO THE SHELL OF THE IGNITER TO DISSIPATE THE RESIDUAL ENERGY.

(4) Instrumentation System

(a) Check engine instrumentation for security and general condition.

(b) Inspect the pressure sensing probes for security.

(c) Visually check all indicating thermocouples for security.

(d) Check the thermocouple harness and all lead insulations and shieldings for chafing and security.

(5) Engine Controls.

(a) Check the power lever for full travel, ease of movment and security.

NOTE: To prevent dilution of the bearing lubricating medium, protect the pre-packed bearings used in the power cross shaft assembly during any washing process. The same precautions must be taken when fuel lines near this assembly are disconnected and fuel is, or may be, in these lines.

(b) Inspect the compressor bleed valve, bleed valve control temperature sensing element and the air tubes for security.

(6) Run Up Area And Engine Inlet Duct

(a) Prior to starting the engine, the inlet must be thoroughly inspected and cleaned of possible loose nuts, bolts, tools, and other objects which could cause engine damage and possible subsequent failure.

(b) Police the inlet and exhaust areas to ensure against the presence of foreign objects which could, under some circumstances, enter the engine.

(7) Water Injection System

(a) Check that the water does not have more than 10 parts per million total solids.

(b) At ambient temperatures below 40°F (4.4°C), check that the water is heated sufficiently to prevent freezing.

G. Starting Procedure

(1) The following starting procedure is applicable to pneumatic starters and to combustion starters when used as pneumatic starters.

NOTE: If the fuel lines have been disconnected or the fuel control has has been drained of fuel, prior to performing the following, bleed vent at the top of the fuel control and motor the engine over with fuel supply ON, the Fuel Control Power Lever at IDLE and the Fuel Control Shut-Off Lever OFF until all the air is bled off. Catch the excess fuel in a container.

(a) Fuel Control Power Lever in IDLE.

(b) Fuel Control Shut-Off Valve Lever OFF.

CAUTION: DO NOT OPEN THE FUEL SHUT-OFF LEVER BEFORE TURNING ON THE STARTER AND THE IGNITION.

(c) Electrical Master Switch ON.

(d) Fuel supply Master Switch ON.

NOTE: Fuel inlet pressure must be 5 psi minimum.

(e) Engine Starter Switch ON.

NOTE: Check for oil pressure rise while cranking.

(f) Ignition switch ON when N_2 speed reaches at least 10 percent.

CAUTION: CHECK FOR ROTATION OF BOTH COMPRESSORS PRIOR TO TURNING IGNITION SWITCH ON.

(g) Fuel Control Shut-off Valve Lever ON.

(h) Ascertain that the engine accelerates normally to IDLE rpm and that the maximum allowable turbine discharge starting temperature, as noted in the Engine Check Table, is not exceeded.

CAUTION: INSUFFICIENT AIR PRESSURE TO A PNEUMATIC STARTER, OR TO A COMBUSTION STARTER THAT IS BEING USED AS A PNEUMATIC STARTER, MAY NOT SUPPLY ENOUGH STARTER TORQUE TO START AN ENGINE PROPERLY, RESULTING IN HOT, HUNG OR "TORCHING" STARTS. WHEN AIRBLEED FROM ANOTHER ENGINE IS USED TO OPERATE THE STARTER, CAUTION IS NECESSARY TO ENSURE THAT THE OPERATING ENGINE IS TURNING OVER FAST ENOUGH TO PROVIDE AN ADEQUATE SUPPLY OF PRESSURIZED AIR TO THE ENGINE BEING STARTED. AN ENGINE SHOULD NEVER BE PERMITTED TO TAKE LONGER THAN 2 MINUTES TO ACCELERATE TO IDLE RPM. IN THE EVENT OF TORCHING, HIGHER THAN USUAL EXHAUST GAS STARTING TEMPERATURES, TOO LONG AN ACCELERATION TIME, OR OTHER ABNORMALITIES DISCONTINUE THE STARTING ATTEMPT AND INVESTIGATE.

(i) Engine Starter Switch OFF when engine attains IDLE rpm.

(j) Ignition Switch OFF.

CAUTION: IF THE FUEL IS SHUT OFF INADVERTENTLY BY CLOSING THE FUEL SHUTOFF LEVER, DO NOT REOPEN THE FUEL VALVE AGAIN IN ATTEMPT TO REGAIN THE "LIGHT". WHENEVER THE ENGINE FAILS TO LIGHT, SHUT OFF THE FUEL AND IGNITION AND CONTINUE TURNING THE COMPRESSOR OVER WITH THE STARTER FOR 10 TO 15 SECONDS TO CLEAR OUT TRAPPED FUEL OR VAPOR. BEFORE ATTEMPTING ANOTHER START, ALLOW EITHER A 30-SECOND FUEL DRAINING PERIOD OR THE PRESCRIBED STARTER COOLING PERIOD, WHICHEVER IS THE LONGER. THE STARTER MAY BE RE-ENGAGED AT ANY TIME AFTER THE COMPRESSOR HAS DECELERATED TO 40 PERCENT RPM OR LESS.

NOTE: The ignition system cycle must also be considered when making a succession of starts or starting attempts. The cycle is two minutes ON - three minutes OFF; two minutes ON - twenty-three minutes OFF. For unsatisfactory starts see paragraph I and J. If it is found necessary to clear the engine, see paragraph K for the proper procedure.

H. Satisfactory Start

(1) A satisfactory start condition exists if the following conditions are met.

(a) Light up takes place within 20 seconds after the Fuel Control Shut-off Valve Lever is placed in the ON position.

(b) The engine accelerates to approximately 58 to 65 percent rpm.

NOTE: The 20 second time interval is an arbitrary value. The actual time to light is dependent upon the amount of torque supplied by the starter.

(c) The exhaust gas temperature does not exceed the starting temperature limits as indicated in the Engine Check Table during transition period to IDLE rpm.

(d) Oil pressure is at least 35 psi.

(e) Exhaust gas temperature reduces to or below that temperature specified for IDLE as indicated in the Engine Check Table after IDLE rpm has been obtained.

I. Unsatisfactory Start

(1) This condition is broken into three phases:

(a) Hot Start. Exhaust gas temperature exceeds the starting temperature limit as specified in the Engine Check Table. A hot start can be anticipated by observing a greater initial starting fuel flow than normal for a given field elevation at the instant the fuel control shut-off valve is placed in the ON position.

(b) No Start. The engine does not light up as evidenced by no rise in exhaust gas temperature, no increase in fuel flow or no sound indicating that fuel has ignited.

(c) False Start. After light up has occurred, the rpm does not increase to that of IDLE, but remains at some lower point with the exhaust gas temperature at or below maximum starting limit.

CAUTION: UNDER ALL CONDITIONS, IF THE FUEL CONTROL SHUT-OFF VALVE LEVER IS INADVERTENTLY MOVED TO THE OFF POSITION, THERE WILL BE AN IMMEDIATE FLAME OUT. DO NOT REOPEN THE SHUT-OFF VALVE AS IT WILL BE IMPOSSIBLE TO REGAIN THE LIGHT. DURING GROUND OPERATION INTRODUCING UNBURNED FUEL INTO THE ENGINE CAN CREATE A FIRE HAZARD AND OVERHEATING OF THE ENGINE AND TAIL PIPE AREA. THE NORMAL STARTING SEQUENCE MUST BE REPEATED FOR EACH STARTING ATTEMPT. CHECK BOTH ROTORS FOR FREEDOM OF ROTATION PRIOR TO STARTING.

J. Unsatisfactory Start Procedure

(1) The following procedure is used in case of an unsatisfactory start:

(a) Fuel Control Power Lever - IDLE.

(b) Fuel Control Shut-Off Valve Lever - OFF.

(c) Ignition Switch - OFF.

(d) Engine Starter Switch - OFF.

(e) Fuel Supply Switch - OFF (When compressors stop rotating).

NOTE: Investigate to find the reason for the difficulty. If a satisfactory start cannot be accomplished, refer to the trouble shooting chart.

(f) A fuel drainage period of at least 30 seconds shall be allowed before another start is attempted.

NOTE: The engine coast down and subsequent motoring prior to the next start is usually sufficient to purge the engine of normal amounts of fuel admitted during an unsuccessful start.

K. Clear Engine Procedure

(1) This operation will be used whenever it is desired to clear the engine of trapped fuel or vapors.

(a) Fuel Control Power Lever - IDLE.

(b) Fuel Control Shut-off Valve Lever - OFF.

(c) Ignition Switch - OFF.

(d) Fuel Supply Switch - ON.

(e) Engine Starting Switch - ON.

(f) Maintain engine rotation for 10 to 20 seconds.

(g) Engine Starting Switch - OFF.

(h) Fuel Supply Switch - OFF. (When compressors stop rotating).

L. Shutdown Procedure

(1) In any instance where the engine has been operated above approximately 85 percent rpm for periods exceeding one minute during the last five minutes prior to shutdown, the engine must be operated at below 85 percent rpm (preferable at IDLE) for a period of five minutes in order to facilitate uniform cooling of parts. Following this five minute run for uniform parts cooling, engine should be accelerated to 75 percent rpm for approximately 30 seconds prior to shutdown to ensure proper oil scavenge from No. 1 bearing area. This applies in particular to periods of prolonged operation at high rpm during engine trimming. If an emergency stop from high power is necessary, both rotors must be checked for freedom of rotation just prior to restarting.

(2) The following steps shall be complied with when shutting down:

(a) Fuel Control Power Lever - IDLE.

(b) Allow time for the cooling period as described above.

(c) Fuel Control Shut-Off Valve Lever - OFF.

NOTE: Fuel Control Shut-off Valve must not be placed in the OFF position when engine speed is above IDLE, except in emergencies.

(d) As the compressors and turbines decelerate after shutdown, ascertain by listening that they do so freely without evidence of rubbing and binding.

(e) Fuel Supply Switch - OFF.

NOTE: Do not turn the fuel supply switch OFF until the engine stops rotating. This will ensure that fuel remains in the lines and that the engine driven fuel pump is properly lubricated.

M. Procedure for Determining Turbine Discharge Pressure (P_{t7}) or Engine Pressure Ratio (P_{t7}/P_{amb}) Values for Trimming and Thrust Checks.

(1) Using the sample curve (Figure 507) as a guide, determine the desired P_{t7} or P_{t7}/P_{amb} values as follows:

CAUTION: FIGURE 507 IS INTENDED AS A GUIDE ONLY. WHEN ACTUALLY TRIMMING OR CHECKING THRUST, THE AIRFRAME MANUFACTURER'S CURVE CORRECTED FOR INSTALLATION LOSSES MUST BE USED.

(a) Determine the ambient air temperature as close to the engine inlet as possible.

(b) Determine the true barometric pressure at the field elevation.

ENGINE - ADJUSTMENT/TEST

(c) Enter the curve at "A" with the temperature.

(d) Proceed downward to the fuel control setting tolerance lines at points "B" and "C".

(e) If P_{t7}/P_{amb} is being employed, proceed horizontally to the right and read the P_{t7}/P_{amb} ratio variation at points "D" and "E".

(f) If a P_{t7} gage is being used, proceed horizontally from points "B" and "C" to that line which denotes the true barometric pressure at points "F" and "G". Drop vertically to the turbine discharge pressure line at points "H" and "J". Note this variation for trimming.

NOTE: The DRY TAKE-OFF, P_{t7} or P_{t7}/P_{amb} value is determined as above except a single (minimum) "setting" line is used.

(g) WET PART THRUST trim and WET TAKE-OFF P_{t7} or P_{t7}/P_{amb} values are determined as above using the applicable water injection curves.

NOTE: The engine may be trimmed and/or checked using water down to an ambient temperature of 20°F (-6.7°C) if provisions are made to heat the water sufficiently to keep it from freezing. If heating facilities are not available, the engine shall be trimmed and/or checked using a 350 psig false reset signal at temperatures between 40°F (4.4°C) and 20°F (-6.7°C). At temperatures below 20°F (-6.7°C) false reset only must be used.

N. Determination of Corrected N_2 Speed

(1) Corrected N_2 speed is determined by the following formula:

$$\text{Corrected } N_2 \text{ rpm} = \frac{\text{Observed } N_2 \text{ rpm}}{\sqrt{\theta}}$$

Where $$\sqrt{\theta} = \sqrt{\frac{\text{Compressor Inlet Temperature } {}^\circ R}{519}}$$

(2) From Figure 508 determine the N_2 correction factor ($\sqrt{\theta}$) for the ambient inlet temperature.

(3) Divide the observed N_2 speed by the $\sqrt{\theta}$.

Example:

Inlet Temperature = 82°F (27.8°C)

$\sqrt{\theta}$ (From Figure 508) = 1.022

Observed N_2 = 9465 rpm

$$\text{Corrected } N_2 = \frac{\text{Observed } N_2 \text{ rpm}}{\sqrt{\theta}} = \frac{9465}{1.022} = 9261 \text{ rpm}$$

O. Engine Adjustments

(1) The only allowable adjustments that can be made to the fuel control are the adjustments to the IDLE, MAXIMUM and WATER INJECTION Trim Screws. Turning the trim screw in a clockwise direction will increase engine speed. All final adjustments should be made in the increase rpm direction.

(2) Oil pressure adjusting screw is under the plug located on the bottom right side of accessory and components drives gearbox front housing. To adjust oil pressure, use PWA 16765 Wrench and remove relief valve plug. Then using PWA 16766 Wrench, turn adjusting screw. Inner portion of tool engages slot of adjusting screw while locknut is loosened with outer portion of wrench. Turn adjusting screw clockwise to increase or counterclockwise to decrease oil pressure. When adjusting oil pressure at idle speed it is permissible to set pressure below 40 psi, but not below 35 psi, in order to assure pressure will remain in 40 - 60 psi range during operation above idle.

P. Test A. Ground Check at Idle

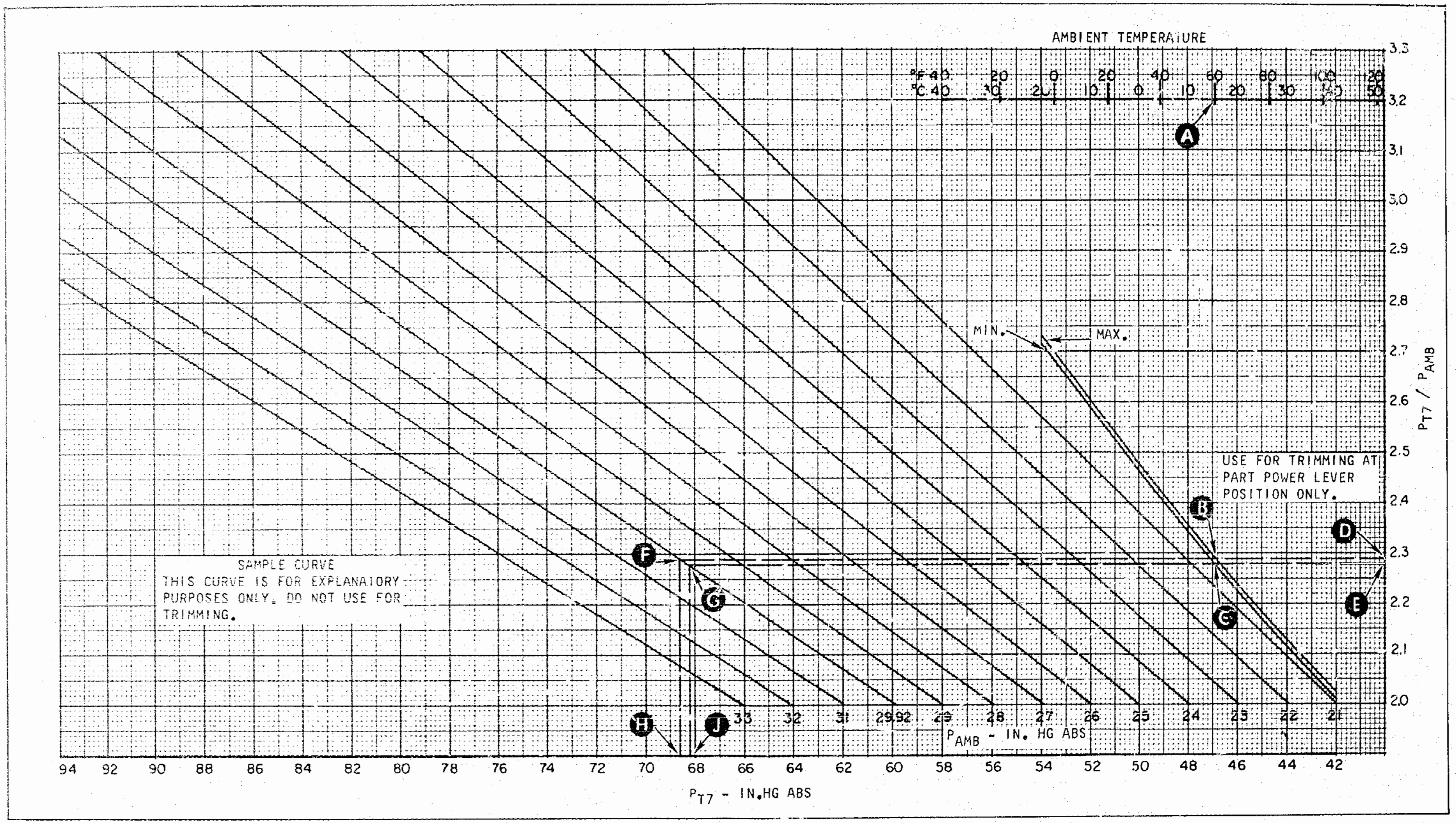
(1) Inspect and clean test area, engine, and engine operating components.

(2) Start engine.

(3) Allow engine to run at IDLE for minimum of five minutes. For oil system repair/replacement, run as required for oil temperature to reach 100°F (38°C).

(4) Shut down.

(5) Inspect engine for evidence of fuel and/or oil leaks.



Sample Trim Curve

Figure 507

ROTOR SPEED CORRECTION FACTOR

T_{t2} °C	(°F)	$\sqrt{\theta}$	T_{t2} °C	(°F)	$\sqrt{\theta}$	T_{t2} °C	(°F)	$\sqrt{\theta}$
48.3	119	1.056	15.0	59	1.000	−18.3	−1	0.940
47.8	118	1.055	14.4	58	0.999	−18.9	−2	0.939
47.2	117	1.054	13.9	57	0.998	−19.4	−3	0.938
46.7	116	1.054	13.3	56	0.997	−20.0	−4	0.937
46.1	115	1.053	12.8	55	0.996	−20.6	−5	0.936
45.6	114	1.052	12.2	54	0.995	−21.1	−6	0.935
45.0	113	1.051	11.7	53	0.994	−21.7	−7	0.934
44.4	112	1.050	11.1	52	0.993	−22.2	−8	0.933
43.9	111	1.049	10.6	51	0.992	−22.8	−9	0.932
43.3	110	1.048	10.0	50	0.991			
42.8	109	1.047	9.4	49	0.990	−23.3	−10	0.931
42.2	108	1.046	8.9	48	0.989	−23.9	−11	0.930
41.7	107	1.045	8.3	47	0.988	−24.4	−12	0.929
41.1	106	1.044	7.8	46	0.987	−25.0	−13	0.928
40.6	105	1.043	7.2	45	0.986	−25.6	−14	0.927
40.0	104	1.042	6.7	44	0.985	−26.1	−15	0.926
39.4	103	1.041	6.1	43	0.984	−26.7	−16	0.925
38.9	102	1.041	5.6	42	0.984	−27.2	−17	0.924
38.3	101	1.040	5.0	41	0.983	−27.8	−18	0.923
37.8	100	1.039	4.4	40	0.982	−28.3	−19	0.922
37.2	99	1.038	3.9	39	0.981	−28.9	−20	0.921
36.7	98	1.037	3.3	38	0.980	−29.4	−21	0.920
36.1	97	1.036	2.8	37	0.979	−30.0	−22	0.919
35.6	96	1.035	2.2	36	0.978	−30.6	−23	0.918
35.0	95	1.034	1.7	35	0.977	−31.1	−24	0.917
34.4	94	1.033	1.1	34	0.976	−31.7	−25	0.916
33.9	93	1.032	0.6	33	0.975	−32.2	−26	0.914
33.3	92	1.031	0.0	32	0.974	−32.8	−27	0.913
32.8	91	1.030	−0.6	31	0.973	−33.3	−28	0.912
32.2	90	1.029	−1.1	30	0.972	−33.9	−29	0.911
31.7	89	1.029	−1.7	29	0.971	−34.4	−30	0.910
31.1	88	1.028	−2.2	28	0.970	−35.0	−31	0.909
30.6	87	1.027	−2.8	27	0.969	−35.6	−32	0.908
30.0	86	1.026	−3.3	26	0.968	−36.1	−33	0.907
29.4	85	1.025	−3.9	25	0.967	−36.7	−34	0.906
28.9	84	1.024	−4.4	24	0.966	−37.2	−35	0.905
28.3	83	1.023	−5.0	23	0.965	−37.8	−36	0.904
27.8	82	1.022	−5.6	22	0.964	−38.3	−37	0.903
27.2	81	1.021	−6.1	21	0.963	−38.9	−38	0.902
26.7	80	1.020	−6.7	20	0.962	−39.4	−39	0.901
26.1	79	1.019	−7.2	19	0.961	−40.0	−40	0.900
25.6	78	1.018	−7.8	18	0.960	−40.6	−41	0.899
25.0	77	1.017	−8.3	17	0.959	−41.1	−42	0.897
24.4	76	1.016	−8.9	16	0.958	−41.7	−43	0.896
23.9	75	1.015	−9.4	15	0.957	−42.2	−44	0.895
23.3	74	1.014	−10.0	14	0.956	−42.8	−45	0.894
22.8	73	1.013	−10.6	13	0.955	−43.3	−46	0.893
22.2	72	1.012	−11.1	12	0.954	−43.9	−47	0.892
21.7	71	1.012	−11.7	11	0.953	−44.4	−48	0.891
21.1	70	1.011	−12.2	10	0.952	−45.0	−49	0.890
20.6	69	1.010	−12.8	9	0.951	−45.6	−50	0.889
20.0	68	1.009	−13.3	8	0.950	−46.1	−51	0.888
19.4	67	1.008	−13.9	7	0.949	−46.7	−52	0.887
18.9	66	1.007	−14.4	6	0.948	−47.2	−53	0.886
18.3	65	1.006	−15.0	5	0.947	−47.8	−54	0.885
17.8	64	1.005	−15.6	4	0.946	−48.3	−55	0.883
17.2	63	1.004	−16.1	3	0.945	−48.9	−56	0.882
16.7	62	1.003	−16.7	2	0.944	−49.4	−57	0.881
16.1	61	1.002	−17.2	1	0.943	−50.0	−58	0.880
15.6	60	1.001	−17.8	0	0.942	−50.6	−59	0.879

L-11336

Rotor Speed Correction Factor Chart

Figure 508

Q. Test B. Ground Check at Intermediate Thrust.

(1) Inspect and clean test area, engine and engine operating components.

(2) Determine P_{t7} or P_{t7}/P_{amb} setting by taking 87 percent of takeoff P_{t7} or P_{t7}/P_{amb} for ambient conditions of the test.

(3) Start engine.

(4) Allow engine to run at IDLE until readings have stabilized; then make following checks:

(a) Fuel Control Shut-Off Valve Lever fully ON and Fuel Control Power Lever-IDLE.

(b) Tachometer 58 to 65 percent rpm.

(c) Exhaust Gas Temperature (see Engine Check Table).

(d) Oil Pressure Gage - 35 psi minimum.

(e) Fuel Pump Warning Light - OFF.

NOTE: If start is made with engine which has cooled to ambient temperature of -31°F (-35°C) or below, it will be preferable to leave power lever at IDLE for two minutes to warm up engine.

(f) Anti-Icing Valves - CLOSED.

NOTE: If running is to be done during icing conditions, anti-icing system must be in operation to prevent icing of engine inlet. During icing conditions with anti-icing system in operation, accurate power check readings of turbine discharge will not be available due to entrance of heated air into engine.

(5) Advance Fuel Control Power Lever to produce turbine discharge pressure value determined in step (2) and maintain for minimum of five minutes.

NOTE: If desired, when advancing power lever, check proper functioning of compressor bleed valve to be within limits of Intercompressor Bleed Control Curve. Operational check of anti-icing system is required only when component parts of this system are removed or disassembled during engine maintenance.

(6) Make certain that operating limits in Engine Check Table are not exceeded.

(7) Do not exceed engine maximum allowable operating speed.

(8) After completion of check, return power lever to IDLE.

(9) Shut down.

(10) Inspect engine for evidence fuel and/or oil leaks.

R. Test C. Ground Check at 4000 lb./hr. Fuel Flow

(1) Inspect and clean test area, engine and engine operating components.

(2) Start engine.

(3) Advance power lever as necessary until minimum of 4000 lb./hr. fuel flow is observed. Maintain for minimum of two minutes.

(4) After completion of check, return power lever to IDLE.

(5) Shut down.

(6) Inspect engine for evidence of fuel and/or oil leaks.

S. Test D. Part Power Trim Check

NOTE: At temperatures below 0°F (minus 18°C) install 0.099 inch thick spacer to obtain power lever angle of 84.5°. Be sure to use applicable Dry Reduced Thrust Trim Curve supplied by aircraft manufacturer. Use of spacers may result in some misalignment of Power Lever, therefore retrim to Dry Part Power Trim Curve as soon as ambient temperature permits.

(1) Inspect and clean run up area, engine, and engine operating components.

(2) From applicable curves, determine turbine discharge pressure values for WET and DRY PART POWER as described in Paragraph M.

(3) Install Part Thrust Trim Stop.

(a) Remove lockwire, compress spring, and rotate trim stop 180 degrees to activated position.

NOTE: Prior to operating newly installed fuel control or one which has been drained of fuel as result of fuel line replacement or filter inspection, air must be bled from fuel control. Open bleed valve at top of fuel control; then motor engine over with fuel supply ON, fuel control power lever at IDLE, and fuel control shut-off valve OFF, until all air has been bled off. Catch excess fuel in container.

(4) Start engine.

(5) Allow engine to run at idling speed until readings have stabilized; then make following checks:

(a) Fuel Control Shut-off Valve Lever fully ON and Fuel Control Power Lever-IDLE.

(b) Tachometer 58 to 65 percent rpm.

(c) Exhaust Gas Temperature (see Engine Check Table).

(d) Oil Pressure Gage - 35 psi minimum.

(e) Fuel Pump Warning Light - OFF.

NOTE: If start is made with engine which has cooled to ambient temperature of -31F (-35°C) or below, it will be preferable to leave power lever at IDLE for two minutes to warm up engine.

(f) Anti-icing Valves - CLOSED.

NOTE: If running is to be done during icing conditions, anti-icing system must be in operation to prevent icing of engine inlet. No trimming of engine will be allowed during icing conditions.

(6) Advance Fuel Control Power Lever until it contacts PART THRUST trim stop.

(7) Allow engine to stabilize and compare stabilized Pt7 or Pt7/Pamb reading with that determined in step (2). Trim engine as necessary.

NOTE: Check that air extraction and accessory utilization is in accordance with requirements of trim curve.

CAUTION: REMOTE TRIMMING EQUIPMENT MUST BE USED, TO PREVENT INJURY TO PERSONNEL.

NOTE: During icing conditions with anti-icing system in operation, accurate trim checks cannot be made.

(8) Following procedure for water injection trimming shall be made only when temperature is 20°F (-6.7°C) or above. With power lever against PART THRUST trim stop, turn water injection switch ON.

NOTE: Water may be used down to ambient temperature of 20°F (-6.7°C) if provisions are made to heat water sufficiently to keep it from freezing. At any time temperature is below 20°F (-6.7°C) or when temperature is between 40°F (4.4°C) and 20°F (-6.7°C) and facilities for heating water are not available, false reset procedures outlined in Paragraph U. must be used.

(9) Check Pt7 reading to meet requirement of applicable WET PART THRUST trim curve as determined in step (2). If Pt7 value does not meet requirements of curve, adjust fuel control Water Injector trimmer until Pt7 value can be met. Make final trim adjustment in increase rpm direction. Turn water injection switch OFF.

(10) Retard power lever to IDLE and check IDLE trim speed. If adjustment to IDLE trim screw is made, it will be necessary to recheck trim at PART THRUST.

(11) Remove Part Thrust Trim Stop.

(a) Rotate trim stop 180 degrees, depressing spring place trim stop in stored position, and lockwire.

(12) If desired, advance power lever to position that will give Pt7 value as determined from applicable curves described in Paragraph M. for DRY TAKE-OFF.

CAUTION: THERE IS NO POWER LEVER STOP AT TAKE-OFF: THEREFORE, DURING ENGINE OPERATION AT TAKE-OFF POWER LEVER POSITIONS, MAKE CERTAIN THAT LIMITING VALUES FOR Pt7, Tt7, N1, AND N2 ARE NOT EXCEEDED.

ENGINE - ADJUSTMENT/TEST

T. Test E. Ground Check For Bleed System Operation.

(1) Inspect and clean test area, engine, and engine operating components.

(2) Start engine.

(3) Allow engine to run at IDLE.

(4) Check that bleed operation occurs at proper N_1 speed as determined by Intercompressor Bleed Control Curve. See Table 1 for bleed valve actuator assembly part number and bleed curve figure number.

(5) Shut down.

(6) Inspect engine for evidence of fuel and/or oil leaks.

U. False Reset Trim Procedure

(1) These procedures apply any time the ambient temperature is below 20°F (-6.7°C) or when facilities for heating the water are not available and the ambient temperature is below 40°F (4.4°C).

(2) Determine P_{t7} or P_{t7}/P_{amb} at which to set engine prior to applying reset signal.

(3) Determine target P_{t7} or P_{t7}/P_{amb} at which engine is to be trimmed after reset signal is applied.

(4) Connect 350 psig signal to false reset fitting on fuel control.

(5) Run engine at P_{t7} or P_{t7}/P_{amb} determined in step (2) above.

(6) Apply 350 psig signal and trim engine to P_{t7} or P_{t7}/P_{amb} determined in step (3) above.

V. Engine Condition Check Based on EPR and Corrected N_2 Speed

(1) Stabilize engine at an EPR of 1.37.

(2) Record observed N_2 speed and ambient temperature.

(3) Correct observed N_2 speed as outlined in paragraph N.

(4) Compare corrected N_2 speed with that stamped on data plate.

(a) If corrected N_2 speed exceeds data plate speed by more than 200 rpm (2 percent), check for leaks in P_{t7} system, anti-icing system, compressor bleed system and for loose covers or caps on engine. If compressor contamination is suspected, perform engine cleaning using water wash or carboblast procedures. See Section 72-0, Engine - Cleaning.

(b) If corrected N_2 speed is 100 rpm or more below data plate speed, perform a hot section inspection and take necessary corrective action.

W. Exhaust Gas Temperature Spread Check

(1) Connect the thermocouple connector to the exhaust gas temperature indicator.

(2) Install Part Thrust trim stop.

(a) For engines with fuel control which has a removable part power trim stop, remove trim stop from storage cavity, check for same serial number as that of fuel control, and install it in threaded hole of power lever locating plate.

(b) For engines with fuel control which has an integral part power trim stop, remove lockwire, compress spring, and rotate trim stop 180 degrees to the activated position.

(3) Start the engine and make the necessary IDLE checks.

NOTE: To obtain a valid temperature spread check, the engine must be properly trimmed.

(4) Advance the power lever to the trim stop. Allow the engine to stabilize and then take readings of the individual thermocouples. The exhaust gas temperature spread, the difference between the lowest and highest reading thermocouples, must not exceed the limits given in the Engine Check Table for PART THRUST operation.

NOTE: If the exhaust gas temperature spread at PART THRUST exceeds the limits and the limit cannot be attained after the equipment used, including thermocouples, is thoroughly checked, perform an exhaust gas temperature spread check at DRY TAKE-OFF power as outlined below. If the temperature spread is within the DRY TAKE-OFF limits, the engine is acceptable. If the DRY TAKE-OFF limits cannot be met, perform a clogged fuel nozzle check to locate the faulty fuel nozzle or nozzles. Replace the nozzles and repeat the spread check.

ENGINE - ADJUSTMENT/TEST

(5) Retard the power lever to IDLE and remove the PART THRUST trim stop.

(a) For engines with fuel control which has removable part power trim stop, remove trim stop from threaded hole in power lever locating plate, check for same serial number as that of control, place in storage cavity, tighten and lockwire.

(b) For engines with fuel control which has an integral part power trim stop, rotate trim stop 180 degrees, depressing the spring place trim stop in the stored position, and lockwire.

NOTE: If the PART THRUST temperature spread check is within limits, the DRY TAKE-OFF temperature spread check (Steps (6) through (8) may be omitted).

(6) Advance the power lever to the predetermined DRY TAKE-OFF P_{t7} value. Allow the engine to stabilize and take readings of the six thermocouples.

(7) Retard the power lever to IDLE and shut down the engine.

(8) If temperature spread, or average temperature exceeds limits given in Engine Check Table; or temperature of any one thermocouple exceeds measured harness average by 100°F (55.5°C), a condition of nozzle flow restriction or improper assembly of combustion chamber liners should be suspected.

(9) Remove the thermocouple test equipment.

X. Engine Overspeed Limits And Inspection Procedures

(1) For engines that incorporate tight (0.004 - 0.012 inch) axial "B" gap at second stage turbine outer airseal.

(a) For JT3D-1, -1A, -1-MC6, -1A-MC6, -1-MC7, -1A-MC7 engines, if N_1 exceeds 6800 rpm (109.9 percent) but does not exceed 7100 rpm (114.8 percent) or N_2 exceeds 10,200 rpm (105.6 percent), but does not exceed 10,500 rpm (108.7 percent), perform inspection procedures outlined in substep (d).

(b) For JT3D-3 engines, if N_1 exceeds 6800 rpm (109.9 percent), but does not exceed 7100 rpm (114.8 percent) or N_2 exceeds 10,250 rpm (106.2 percent), but does not exceed 10,500 rpm (108.7 percent) perform inspection procedures outlined in substep (d).

(c) For JT3D-3B, JT3D-3C engines, if N_1 exceeds 6850 rpm (110.7 percent), but does not exceed 7100 rpm (114.8 percent) or N_2 exceeds 10,300 rpm (106.7 percent), but does not exceed 10,500 rpm (108.7 percent) perform inspection procedures outlined in substep (d).

ENGINE - ADJUSTMENT/TEST

(d) Prior to any additional operation, check rotors for free rotation and visually inspect inlet and exhaust ducts for foreign particles or evidence of blade rub or vane nicking. If found satisfactory, continue engine in service after correcting cause of overspeed. If any abnormal conditions are evident, further inspection is necessary.

(e) If N_1 exceeds 7100 rpm (114.8 percent) or N_2 exceeds 10,500 rpm (108.7 percent), shut down as soon as possible and send engine to overhaul for complete inspection.

(2) For engines that do not incorporate tight axial "B" gap at second stage turbine outer airseal.

(a) If N_1 speed exceeds 6800 rpm (109.9 percent) for JT3D-1, -1A, -1-MC6, -1A-MC6, -1-MC7, -1A-MC7, -3 engines or 6850 rpm (110.7 percent) for JT3D-3B, -3C engines, a one-time flyback, not to exceed two take off cycles, is authorized to return engine to overhaul for tear down inspection. See Section 72-00, Engine General - Testing of overhaul manual for specific inspection requirements.

(b) If N_2 speed exceeds 10,200 rpm (105.6 percent) for JT3D-1, -1A, -1-MC6, -1A-MC6, -1-MC7, or -1A-MC7 or 10,250 rpm (106.2 percent) for JT3D-3 or 10,300 rpm (106.7 percent) for JT3D-3B, -3C but does not exceed 10,500 rpm (108.7 percent), perform inspection procedures outlined in step (c).

(c) Prior to any additional operation, check rotors for freedom of rotation and visually inspect inlet and exhaust ducts for foreign particles or evidence of blade rub or vane nicking. If found satisfactory, continue engine in service after correcting cause of overspeed. If any abnormal conditions are evident, further inspection is necessary.

(d) If N_1 exceeds 7,100 rpm (114.8 percent) or N_2 exceeds 10,500 rpm (108.7 percent), shut down as soon as possible and send engine to overhaul for complete inspection.

ENGINE - ADJUSTMENT/TEST

Y. Overtemperature Limits and Inspection Procedure

CAUTION: WHEN EGT LIMITS ARE EXCEEDED, ENGINE SHOULD NOT BE SHUT DOWN ON AN EMERGENCY BASIS, BUT SHOULD BE COOLED FOR 5 MINUTES UNLESS IT IS OBVIOUS THAT CONTINUED OPERATION WILL RESULT IN ADDITIONAL ENGINE DAMAGE. REGARDLESS OF HOW ENGINE IS SHUT DOWN, IT SHOULD NOT BE RESTARTED UNTIL INSPECTION SHOWS THAT BOTH ENGINE ROTORS WILL ROTATE NORMALLY.

(1) If EGT exceeds limit given in Engine Check Tables, engine has been subjected to an overtemperature condition. The remedial action which must be taken depends on the degree of temperature reached, the length of time at the temperature, and the condition at which the engine was being operated at the time. Figures 509 through 511A present graphically the action to be taken when the engine has been subjected to an overtemperature condition. Perform the applicable inspection as outlined in steps (2) and (3).

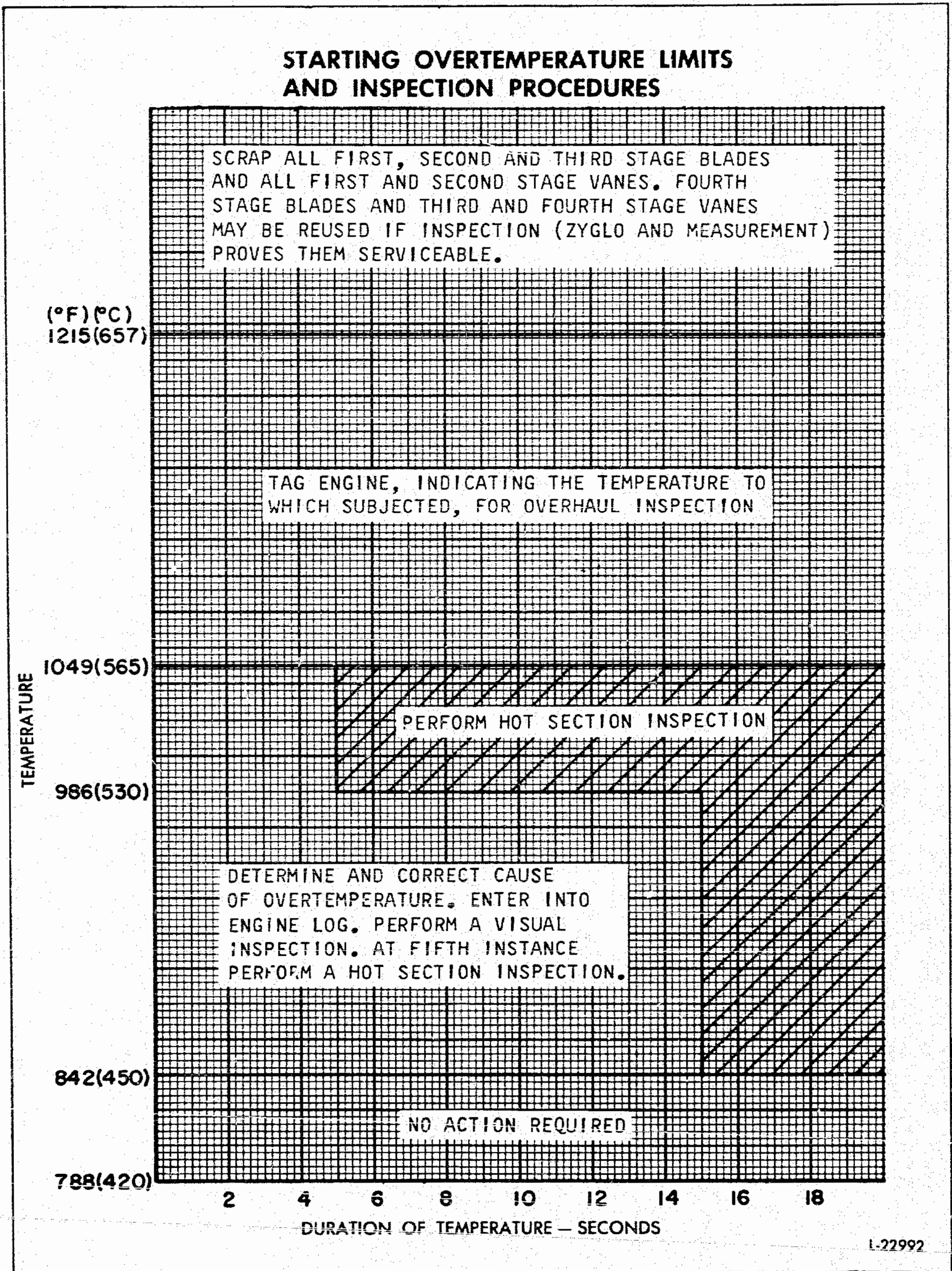
(2) A visual inspection shall consist of inspecting the exhaust duct and the rear of the turbine for any apparent damage.

(3) A hot section inspection shall consist of the following:

(a) Inspect exhaust duct and rear of turbine for apparent damage.

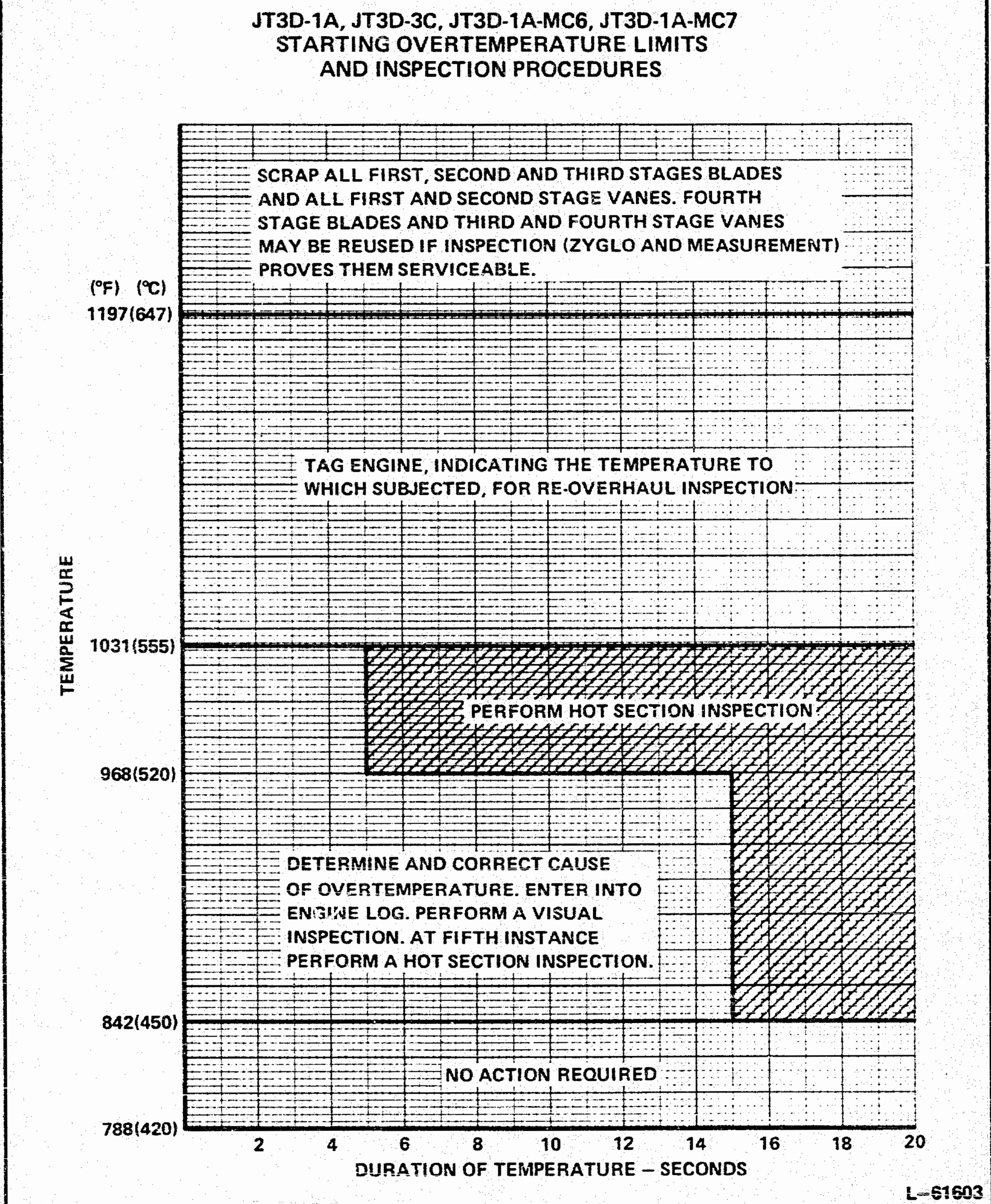
(b) Slide combustion chamber rearward, remove combustion chambers and inspect burner section and turbine nozzle guide vanes. Remove section of vanes and inspect first stage turbine blades. Subject parts should be inspected for excessive distortion.

(c) If results are satisfactory, engine may be continued in service after cause of overtemperature has been found and corrected. Perform stretch check on first stage turbine blades. If any blade exceeds maximum allowed stretch limit entire turbine shall receive complete overhaul inspection.

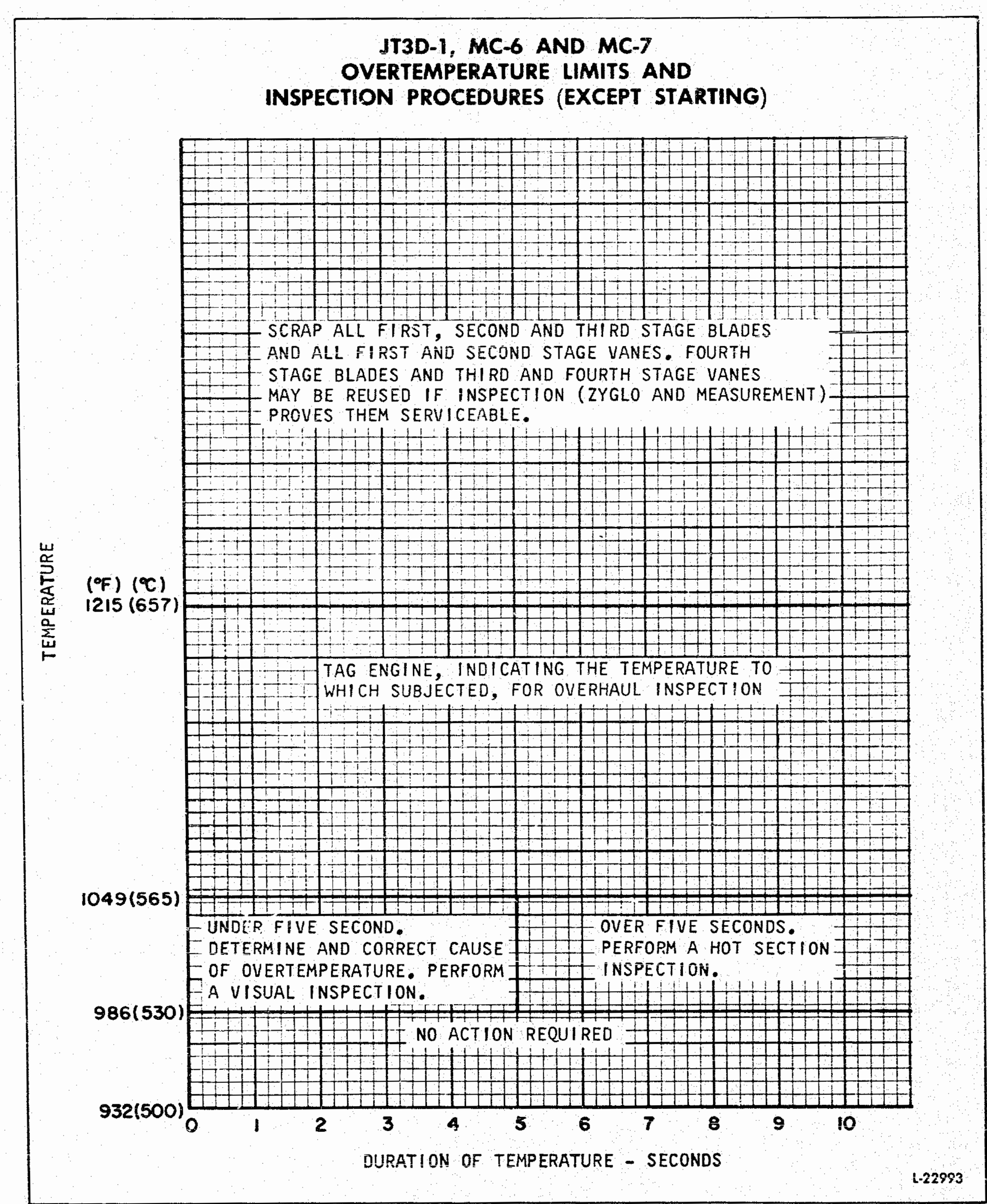


JT3D-1, D-3, D-3B, MC-6, and MC-7 Starting Over-Temperature Limits and Inspection Procedures

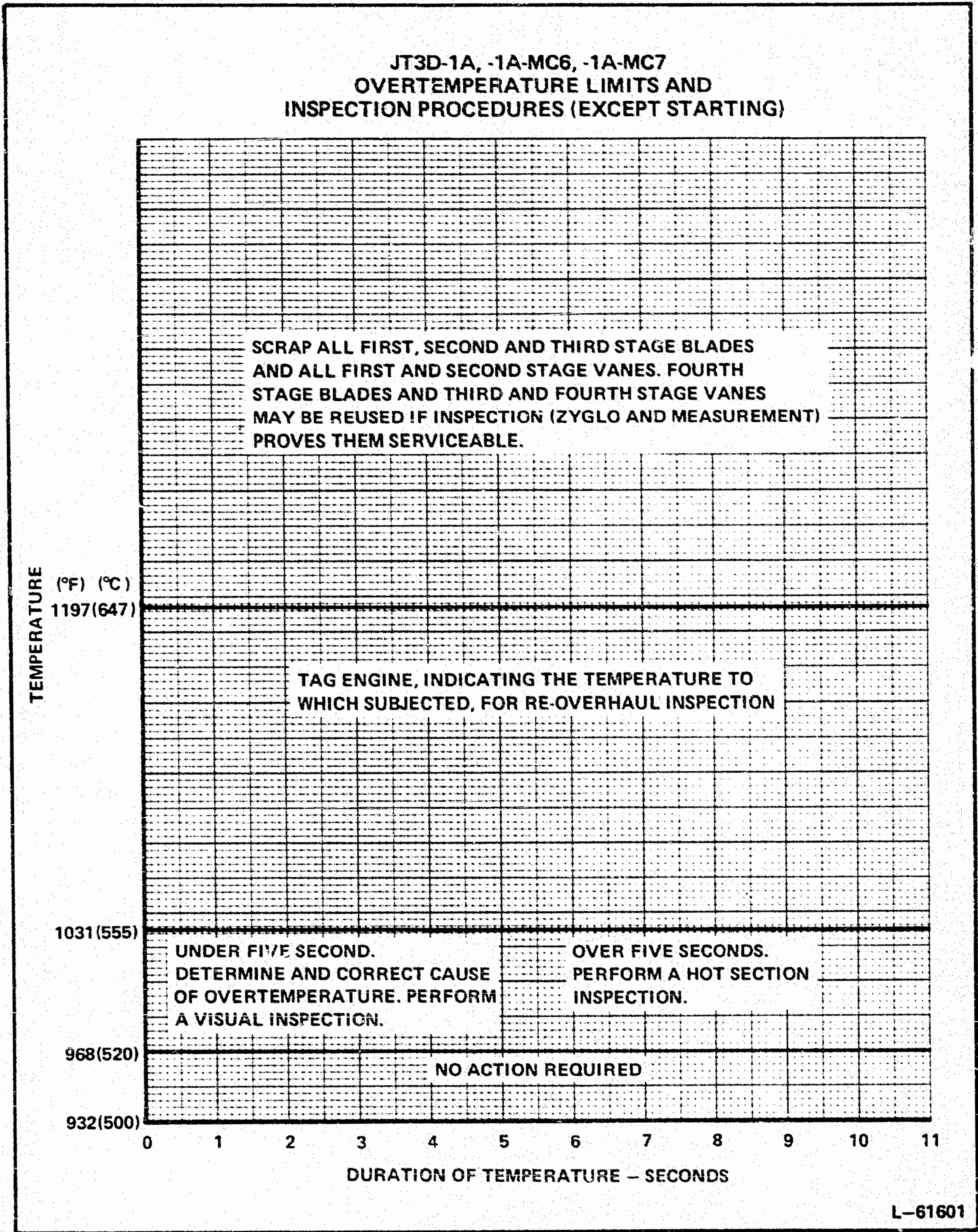
Figure 509



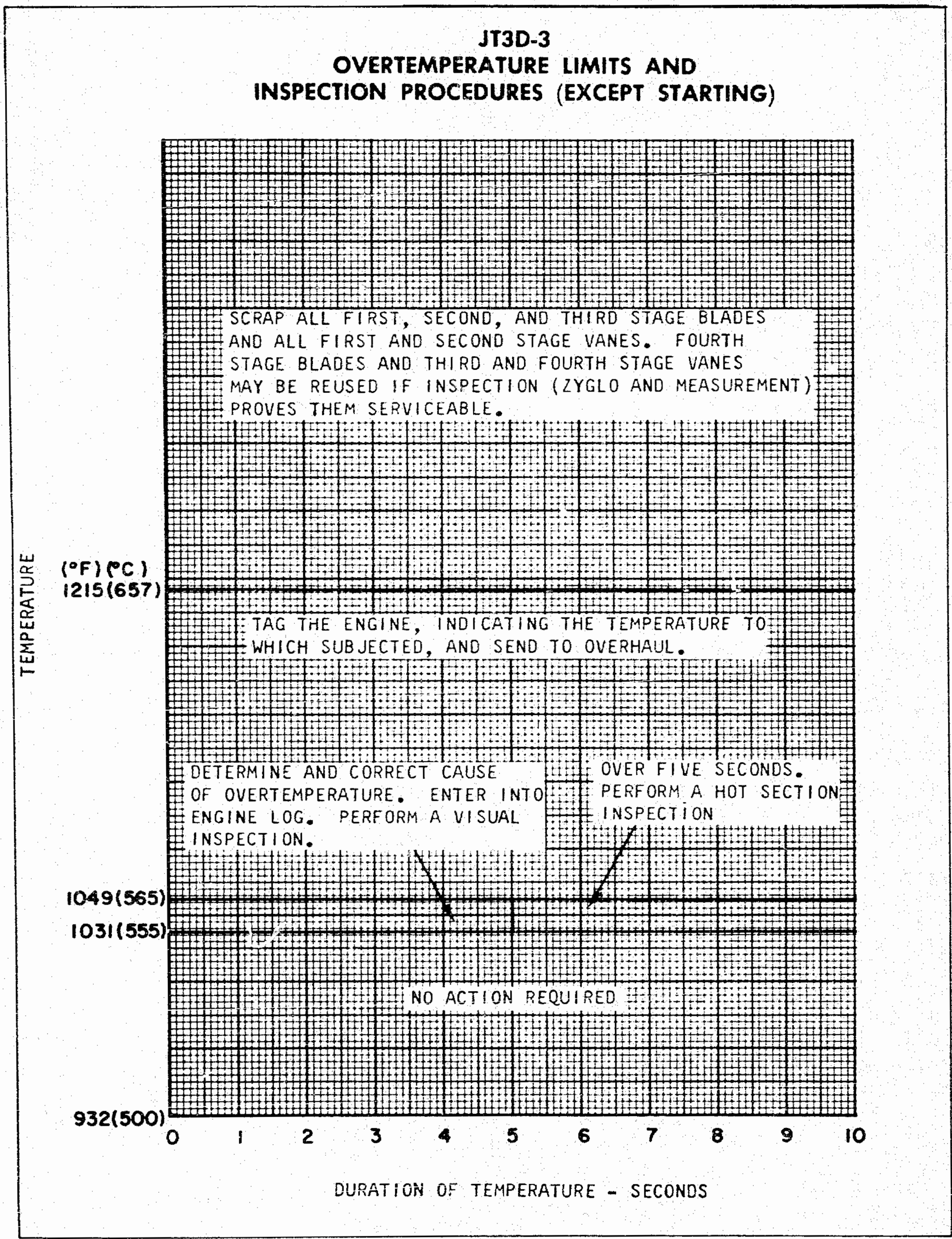
JT3D-1A,-1A-MC6,-1A-MC7, And -3C
Starting Overtemperature Limits
And Inspection Procedures
Figure 509A



JT3D-1, MC-6, and ~~MC-7 Take-Off Overtemperature~~
Limits and Inspection Procedures

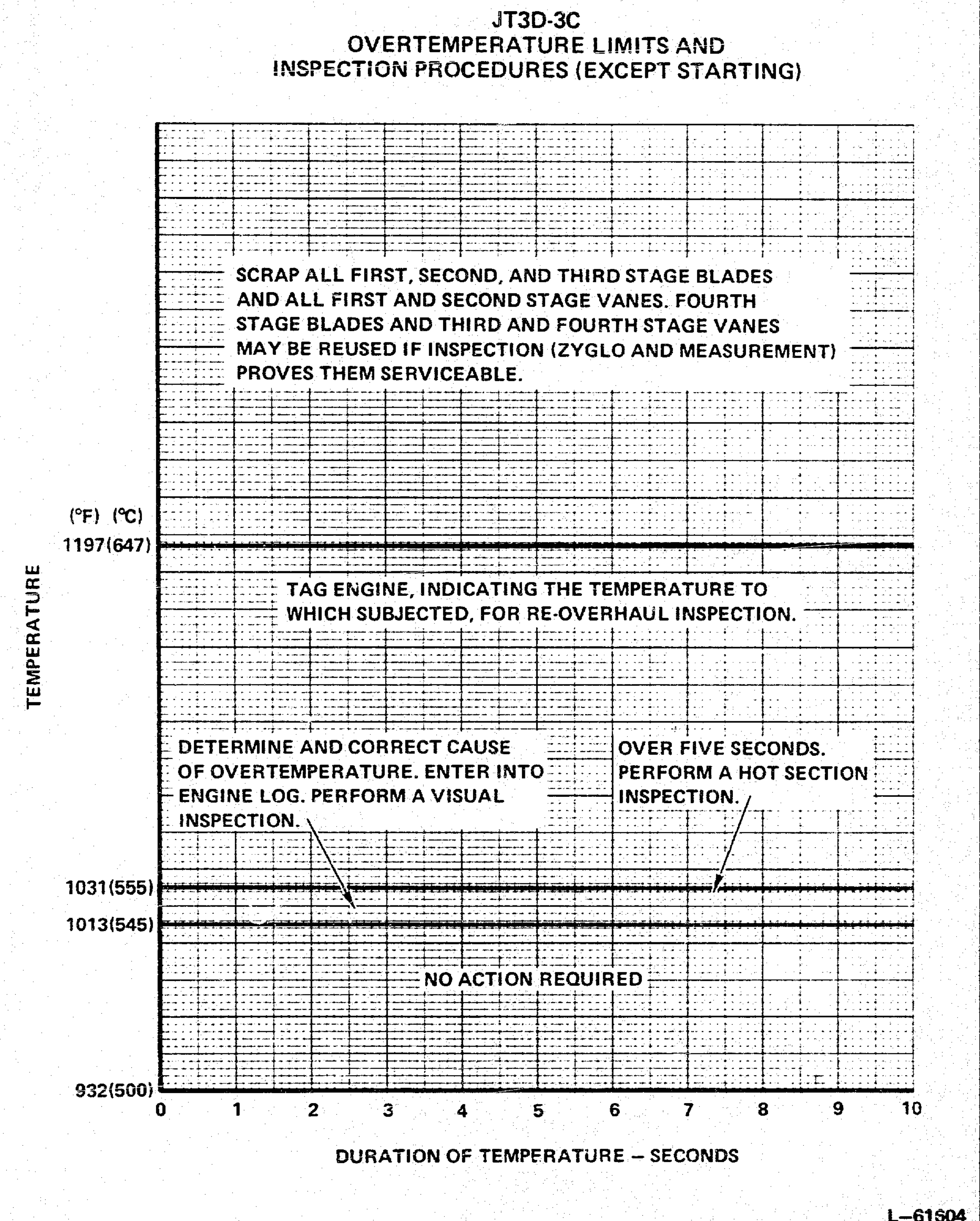


JT3D-1A,-1A-MC6,-1A-MC7 Take-Off
Overtemperature Limits And
Inspection Procedures
Figure 510A



JT3D-3 and D-3B Take-Off Overtemperature
Limits and Inspection Procedures

Figure 511



JT3D-3C Take-Off Overtemperature
Limits And Inspection Procedures
Figure 511A

ENGINE - ADJUSTMENT/TEST

(d) If the inspection indicates possible internal damage, all turbine disk and blade assemblies, turbine nozzle guide vanes (all stages) and inner shrouds must be tagged indicating the overtemperature to which subjected and given a complete overhaul inspection.

2. Numerical Tool List

PWA 16765 Wrench
PWA 16766 Wrench

ENGINE - INSPECTION/CHECK

1. Periodic Inspection

A. General

(1) These inspection procedures are a normal function of operating organizations. They consist of required inspections and minor adjustments necessary on the engine. The nature and conditions of engine operation determine the time interval between required inspections. For this reason, the intervals described in the Periodic Inspection Chart in this section are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because the extensive mass air flow tends to draw foreign objects into the engine. Thoroughly clean the entire engine compartment with a vacuum cleaner after completion of any work. Keep the compartment free of dirt, oil and grease, and remove all unused parts, such as nuts, washers, and pieces of lockwire. Immediately cover all apertures resulting from the disconnection of tubing or parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect the exterior of the engine without dismantling to ensure that all connections are tight and free from leaks and that lines, tubing, and controls are secure and properly locked.

(4) Check all engine controls for proper operation. Make certain that the linkage from the cockpit controls to the engine units are connected in a manner that permits full and free movement with sufficient friction to hold the control in the required position. See that the controls are adjusted to permit overtravel of the control lever to ensure full operation of the engine unit.

(5) Suitable inlet cowl covers should be used during aircraft towing and at all times when not in service. As soon as the engine has cooled sufficiently after operation, a suitable exhaust nozzle cover should be installed.

(6) Service life of certain engine parts is limited by maximum number of hours or cycles. Hours is defined as that accumulated time from the moment an aircraft leaves the surface of the Earth until it touches it at the next point of landing (flight time). In addition to keeping track of operating hours, an accurate record of cycles must be maintained. A cycle is defined as any flight consisting of one take-off and landing regardless of length of flight or whether or not thrust reverser was used. Touch and go landing and take-off is included in this definition.

NOTE: This definition of a cycle applies to engines in normal airline usage including a moderate amount of routine pilot training. Any extended special usage such as might be incurred by assignment of one aircraft to extensive pilot training use for several months or assignment of any engine to a flight test vehicle requires that any throttle changes equal to or greater than idle-to-maximum continuous, inflight or on the ground, be recorded as a cycle in obtaining the total cycles on an engine part.

ENGINE - INSPECTION/CHECK

(7) Service life of disks is to be limited to maximum accumulated hours or cycles, whichever occurs first. Refer to Overhaul Manual for maximum time or cycles on front compressor front hubs and disks for each engine model. Refer to Section 70-30, Standard Practices Manual, for additional information on service life.

B. Periodic Inspection Chart

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
ENGINE GENERAL				
External Tubing, Hoses and Electrical Leads	a. Security of all accessible connections, clamps, and brackets.	X	X	X
	b. Evidence of chafing and wear.	X	X	X
	c. Evidence of fuel or oil leakage.	X	X	X
Engine Mounts	a. Security of installation.			X
COMPRESSOR				
Inlet Guide Vanes	a. Nicks, dents or other evidence of passage of foreign material.	X	X	X
Inlet Case Cracks	a. Check for cracks in these locations: (Refer to specific periodic inspection for crack limits).			
	1. Inner Shroud			
	2. Outer Shroud			
	3. Vane-to-shroud welds	X	X	X
	4. Check for stripped attaching bolt hole threads in rear outer flange.	X	X	X
Compressor Blade Locks - First Stage Fan	a. Check for looseness. See specific periodic inspection for limits.	X	X	X
Compressor Blades See Figure 601.	a. Nicks, dents or other evidence of passage of foreign material.	X	X	X
Compressor Vanes, See Figure 602 and Fan Discharge Case Struts, See Figure 603.	a. Nicks, dents or other evidence of passage of foreign material.	X	X	X
	b. Case may be used with a maximum of 10 cracked struts without repair provided each crack is not over 1/2 inch long and does not extend into fillet area.	X	X	X

ENGINE - INSPECTION/CHECK

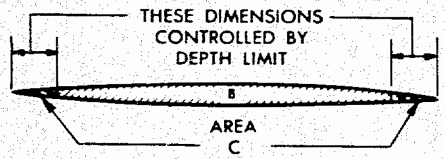
Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
COMPRESSOR (continued)				
Diffuser Case	a. Check for bulged and discolored areas which betray fuel nozzle or manifold discrepancies.	X	X	X
COMBUSTION CHAMBER, TURBINE AND EXHAUST SECTION				
Combustion Chamber Case	a. Cracks, dents, distortion and hot spots.	X	X	
Fuel Manifold and Nozzle Assembly	a. Remove assembly and replace with reconditioned unit.			X
Fireseal	a. Cracks	X	X	
Combustion Chambers	a. Cracks, warpage and localized overheating. b. Cracked, broken or worn locating flange lugs.			

MAXIMUM ALLOWABLE REPAIR LIMITS – INCHES

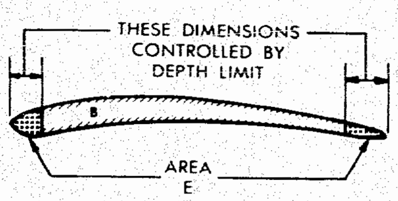
BLADE AREA		STAGES 1 AND 2
	A	3/4 R
	B	1/32 RB
	C	3/8 D
	D	NONE
	E	1/4 D
	F	1/16 D

R – RADIUS D – DEPTH
RB – ROUND BOTTOM

DAMAGE TO THE LEADING EDGE OF THE BLADES WITHIN TWO INCHES OF THE TIP MAY BE BLENDED TO A MAXIMUM DEPTH OF ⅜ INCH FOR A MAXIMUM OF SEVEN BLADES PER ENGINE.



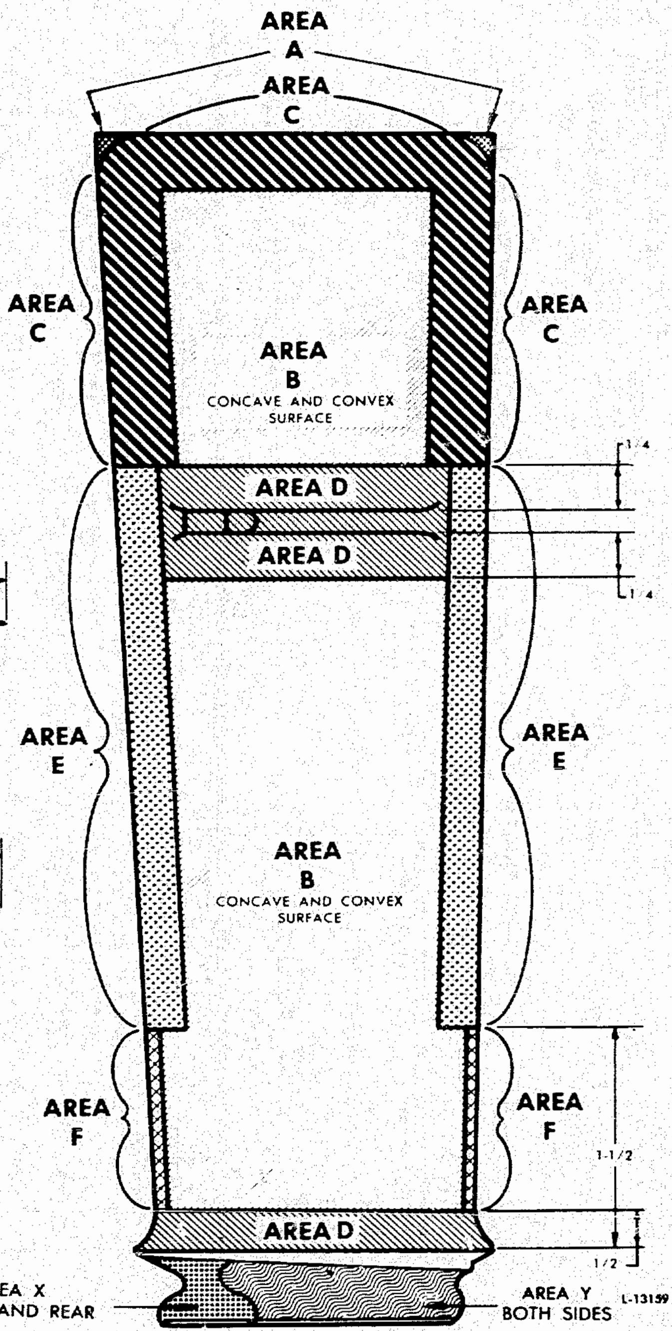
CROSS SECTION OF FAN BLADE ABOVE PART SPAN SHROUD



CROSS SECTION OF FAN BLADE BELOW PART SPAN SHROUD

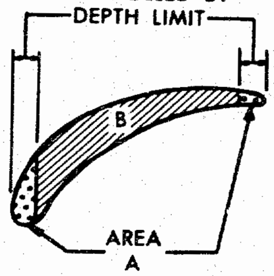
CAUTION

THE LIMITS REFERRED TO IN THIS FIGURE IN AREAS "C", "E" AND "F" PERTAIN TO LOCAL, ISOLATED, DAMAGED AREAS ONLY AND MUST NOT BE INTERPRETED AS AUTHORITY FOR REMOVAL OF MATERIAL ALL ACROSS THE TIP AND LEADING OR TRAILING EDGES AS MIGHT BE DONE IN A SINGLE MACHINING CUT.



Compressor Fan Blades Inspection and Repair Limits

Figure 601

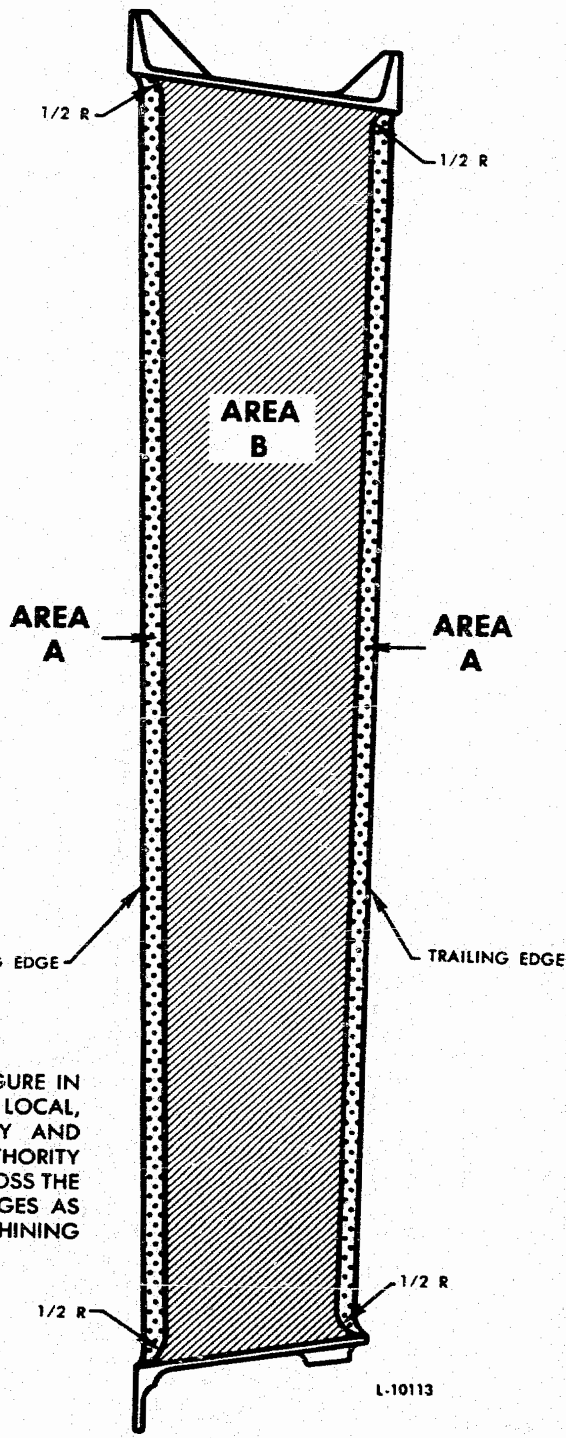


CROSS SECTION
OF VANE

MAXIMUM ALLOWABLE
REPAIR LIMITS — INCHES

VANE 1ST STAGE		
	A	1/4 D
	B	1/64 RB

R — RADIUS D — DEPTH
RB — ROUND BOTTOM

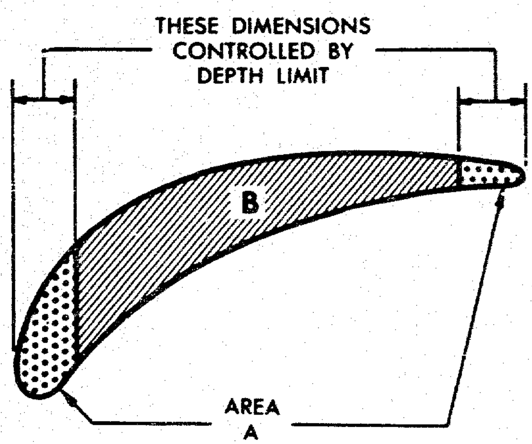


CAUTION

THE LIMITS REFERRED TO IN THIS FIGURE IN THE AREAS "A" AND "B" PERTAIN TO LOCAL, ISOLATED, DAMAGED AREAS ONLY AND MUST NOT BE INTERPRETED AS AUTHORITY FOR REMOVAL OF MATERIAL ALL ACROSS THE TIP AND LEADING OR TRAILING EDGES AS MIGHT BE DONE IN A SINGLE MACHINING CUT.

First Stage Vane Inspection
and Repair Limits

Figure 602



CROSS SECTION
FAN EXIT STRUT

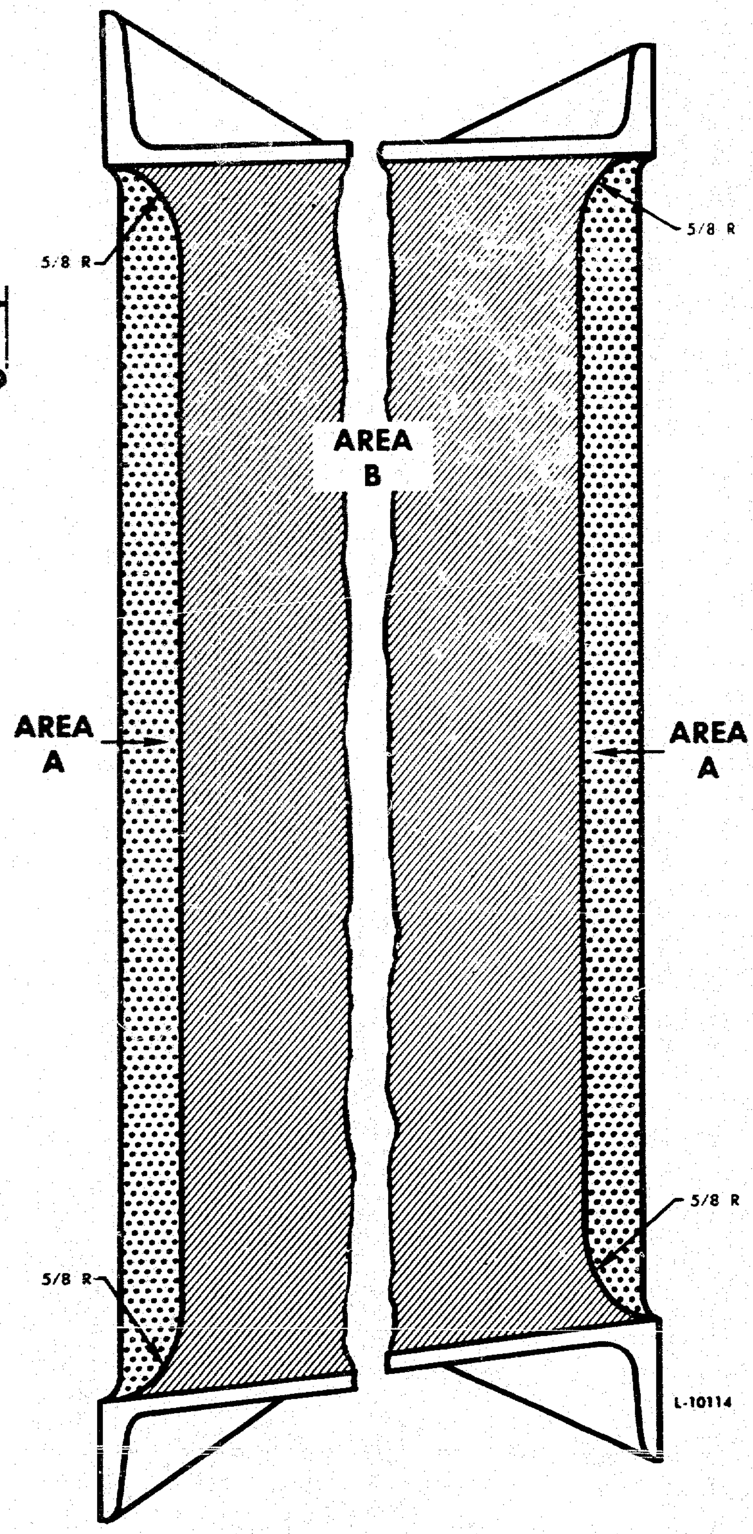
MAXIMUM ALLOWABLE REPAIR LIMITS — INCHES

	VANE FAN EXIT	
	A	5/16 D
	B	1/64 RB

R — RADIUS D — DEPTH
RB — ROUND BOTTOM

CAUTION

THE LIMITS REFERRED TO IN THIS FIGURE IN THE AREAS "A" AND "B" PERTAIN TO LOCAL, ISOLATED, DAMAGED AREAS ONLY AND MUST NOT BE INTERPRETED AS AUTHORITY FOR REMOVAL OF MATERIAL ALL ACROSS THE TIP AND LEADING OR TRAILING EDGES AS MIGHT BE DONE IN A SINGLE MACHINING CUT.



Fan Discharge Case Strut Inspection
and Repair Limits

Figure 603

ENGINE - INSPECTION/CHECK

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
Combustion Chambers	c. Proper positioning of flame cross-over tubes.			
Combustion Chambers Outlet Duct	a. Cracks and deterioration.			
Turbine Case	a. Localized overheating and warpage.		X	
First Stage Turbine Nozzle Guide Vanes	a. Cracks, burning or impact damage.			
	b. Bowed vanes.			
First Stage Turbine Blades	a. Cracks or warpage.			
	b. Dents, nicks or other evidence of indicating passage of foreign material. Use a strong light.			
Fourth Stage Turbine Blades	a. Cracks or warpage.			
	b. Dents, nicks or other evidence indicating passage of foreign material.			
Fourth Stage Nozzle Vanes	a. Trailing edge for cracks and distortion. Rotate turbine and use a strong light.			
Turbine Exhaust Struts	a. Distortion, cracks, nicks, and erosion.			
	b. Evidence of broken strut retaining lugs.		X	

ACCESSORY SECTION

Accessory and Component Drives Gearbox	a. Check for oil leaks.	X	X	X

ENGINE - INSPECTION/CHECK

Component	Nature of Inspection	Inspection Time Routine	Minor	Major
CAUTION: DO NOT TURN OR ATTEMPT TO TURN THE FOUR CASTLE NUTS IN THE CENTER PORTION OF THE OIL PUMP ASSEMBLY. THESE NUTS ARE LOCKWIRED AND SECURE THE OIL PUMP THROUGH BOLTS. THESE NUTS MAY BE TIGHTENED ONLY WHEN THE PUMP IS OUT OF THE GEARBOX ASSEMBLY.				
OIL SYSTEM				
NOTE: There have been reported instances of No. 1 Bearing Compartment Static Oil seepage due to residual oil not being scavenged from the bearing (No. 1) compartment prior to shutdown. One way to ensure that excessive residual oil is not being left in the bearing compartment is to run the engine up to 75 percent power prior to shut down if oil seepage is felt to be objectional. However this run up may not always be convenient to perform. In this instance the following limits may be applied: a. 10cc's of oil seepage per hour from the No. 1 Bearing Compartment is allowable if it is inconvenient to run engine up to 75 percent power prior to shut down. b. The 10cc limit may not be measurable and should diminish over a relatively short period of time after shut down. The seepage would be considered acceptable if it only wets the surfaces and does not accumulate into a puddle.				
CAUTION: DO NOT MIX DIFFERENT BRANDS OF OIL WHEN CHANGING OIL OR ADDING OIL BETWEEN CHANGES, SINCE THE CHEMICAL STRUCTURE OF DIFFERENT BRANDS OF SYNTHETIC OIL MAY DIFFER SUFFICIENTLY TO MAKE THEM INCOMPATIBLE WITH EACH OTHER.				
Oil*	a. Check oil level.	X	X	X
NOTE: Oil should be checked and added as required within two hours after shutdown.				
*See Paragraph C below.				
Oil Filter*	a. Metal particles and other foreign matter.		X	X
*See Paragraph C below.	b. Damaged screens and spacers.		X	X
	c. Proper installation and leakage.		X	X

ENGINE - INSPECTION/CHECK

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
	d. Adequate assembly tension (cannot rotate screen elements by hand).		X	X
Oil Scavenge Pump Inlet Strainer See Paragraph C(3) below.	a. Metal Particles and other foreign matter.		X	X
Differential Pressure Switch (Delta P). See subparagraph C.	a. Actuation		X	X
BREATHER SYSTEM				
Breather Line Connection (Top of Diffuser Case)	a. Remove, clean, and reinstall.			X

C. Specific Periodic Inspection

(1) Oil Change

(a) Oil Changes are not required if engine is operated 300 or more flight hours per year. For operation or less than 300 flight hours per year an oil change every six (6) months is recommended. See P&W Service Bulletin No. 238 for approved oils and methods for conversion to another brand of oil.

NOTE: When checking oil level and to facilitate a complete oil drain, engine should be operated for at least one minute at idle speed to assure that any oil which may be in the scavenge section of the engine is returned to the oil tank. When draining oil immediately after shut down, it is only necessary to drain the oil tank to effect a complete oil change. Unlimited lapse of time between shutdown and oil drainage is permitted providing oil is drained from the N2 gearbox in addition to the oil tank.

(2) Main Oil Strainer.

(a) Remove main oil strainer for inspection at every oil change and/or when any excessive vibration is experienced (over limits) or when any erractic change to oil pressure is noted (below 30 or above 55 PSIG).

NOTE: Main oil strainer inspection frequency shall not exceed 500 hours regardless of oil change frequency.

(b) Perform the following procedure if a few finely divided metal particles are found at the first strainer check after installation of a new or newly overhauled engine:

NOTE: Discovery of fine metal particles is not uncommon and is not normally cause for concern.

(c) Clean and reinstall the strainer.

(d) Operate the engine for at least ten minutes but not more than twenty minutes; then recheck the strainer.

(e) If there is no increase in the quantity of the metal particles the engine may be returned to service.

(f) When metal is found in oil strainer during routine inspection, strainer shall be cleaned or replaced and engine ground run at part power setting. Engine should be accelerated from idle to part power stop five times, then run at part power for approximately 20 minutes. Recheck strainer and, if clean, engine is ready for service. Check strainer after approximately 50 hours of operation.

NOTE: The 20 minute part power run may be reduced to 10 minutes, if desired, or to comply with airport noise regulations.

(g) Any engine not incorporating a main oil strainer by-pass warning system that has been partially disassembled to the extent of exposing any bearing compartment except No. 1 bearing must have the main oil screen disassembled, inspected and cleaned at periods not to exceed 12 hours. Screen checks will be continued until the screen is free of contamination for 2 successive inspections.

CAUTION: IF CONTAMINANTS INDICATE ENGINE PART FAILURE OR CONTAMINANTS IN SUFFICIENT QUANTITY TO PLUG THE OIL SCREEN ARE FOUND DURING ANY INSPECTION THE ENGINE MUST NOT BE OPERATED UNTIL THE CAUSE OF THE DIFFICULTY HAS BEEN DETERMINED AND SATISFACTORILY CORRECTED.

(3) Oil Scavenge Pump Inlet Strainer

(a) Check scavenge pump inlet strainer after installing a new, repaired or overhauled engine. If the strainer is clean, no further action is required. If the strainer is contaminated, clean it, replace and check as for main oil strainer. See preceding paragraph C.(2)(b).

(b) During subsequent operation of the engine there should be no further need to inspect this strainer unless the main oil strainer is found contaminated in which case, perform the above.

ENGINE - INSPECTION/CHECK

(4) Check differential pressure switch for actuation. Warning light should turn on at 50 $\pm$ 1.5 psi and should remain on as long as differential pressure is 50 $\pm$ 1.5 psi or greater.

(4a) Fan Discharge Case - Strut Cracks

(a) Fan discharge case struts with cracks exceeding limits specified in Periodic Inspection Chart may be continued in operation for a period not to exceed 150 hours provided cracks are not of a converging nature or could possibly liberate pieces, and only one crack per strut.

(5) Inlet Case Cracks - Limits of Acceptability.

NOTE: An inlet case with cracks exceeding limits of acceptability may be continued in operation for a period not to exceed 150 hours, provided cracks are not of a converging nature or could possibly liberate pieces.

(a) If a crack in excess of one inch in outer surface of inner shroud is noted at inspection, it will be necessary to examine welds at inner end of inlet vanes and inner shroud flange to assure that inner end of vane is not breaking loose from inner shroud. This examination of inner surface of inlet case inner shroud can be made by looking through anti-icing holes in No. 1 bearing support web.

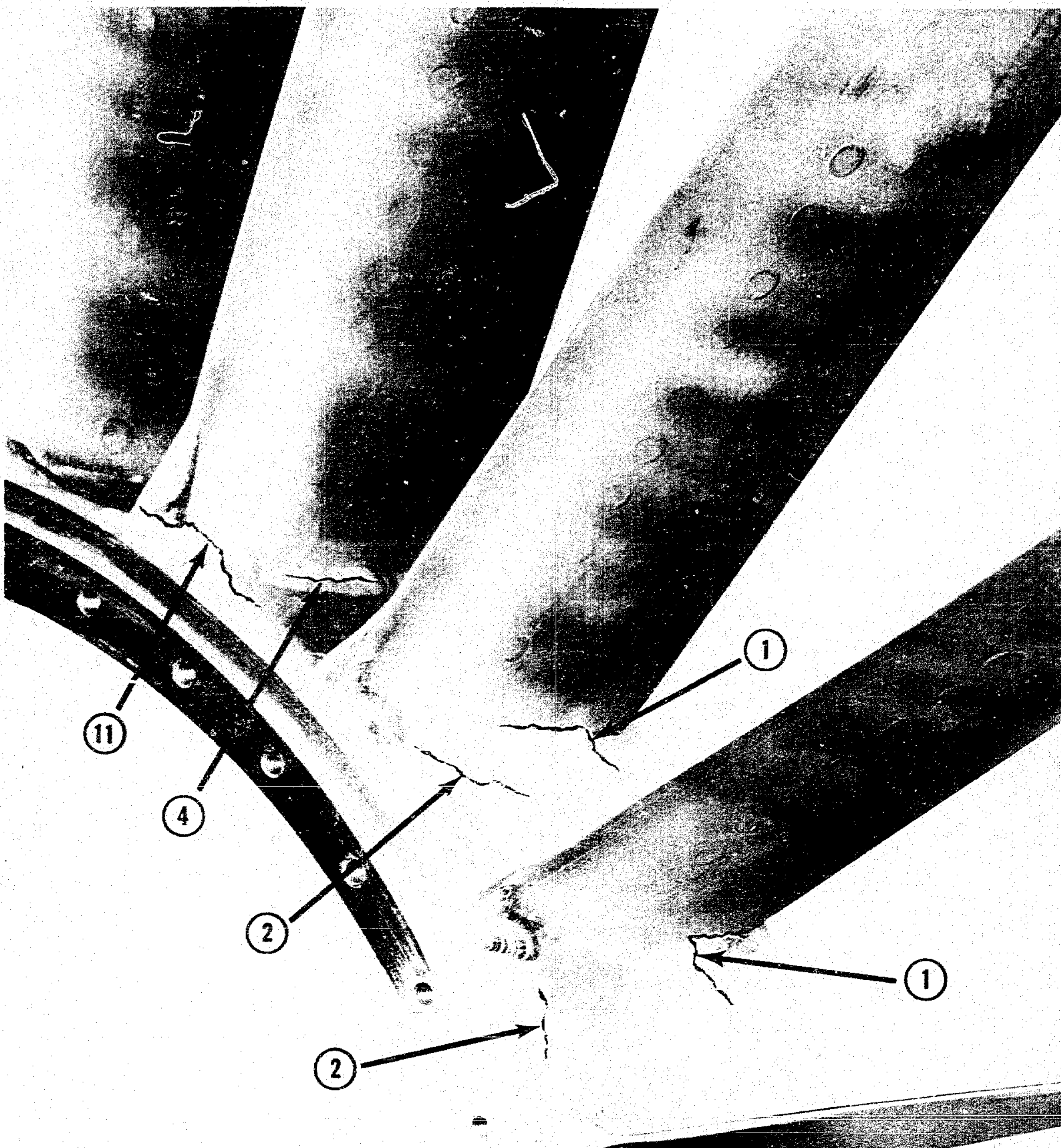
NOTE: Multiple cracks which indicate possible joining in such a manner so as to permit piece of shroud to enter inlet airstream, are not acceptable.

(b) For cracks running adjacent to weld bead and transversing weld bead, inlet case must be removed and cracks weld repaired. See Index 1, Figure 604.

NOTE: If type of crack noted above is found at a remote line station, periodic inspection must be made until aircraft returns to a station capable of repairing case.

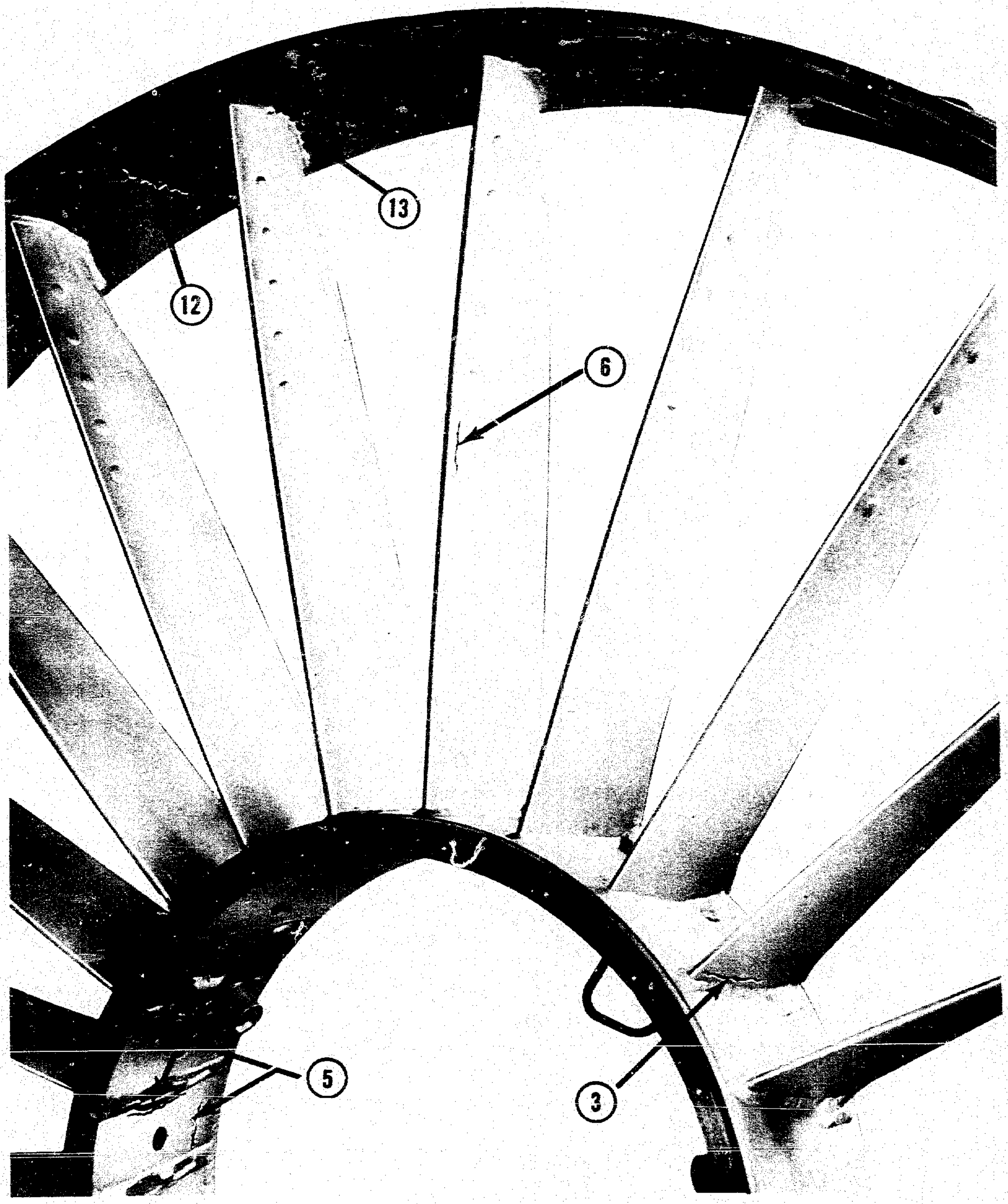
(c) Cracks in outer shroud inner box and inner shroud outer box (Index 2, Figure 604) are acceptable up to three inches in length if wholly contained in shroud skin and are not associated with cracks originating in vane skin at leading or trailing edges. These cracks are not to be of a converging nature. No more than three cracks are permitted in any 90 degree segment.

(d) Cracks in inner and outer vane and welds adjacent to vane skin (Index 3, Figure 605) are to be repaired when aircraft returns to maintenance station capable of making such repairs.



Inlet Case Crack Limits

Figure 604



Inlet Case Crack Limits

Figure 605

ENGINE - INSPECTION/CHECK

(e) Cracks in vane to shroud welds proper (Index 4, 13, Figures 604, 605) are acceptable up to three inches maximum in 50 percent of vanes.

(f) Cracks in inner box segment (Index 5, Figure 605) are acceptable up to three inches maximum. These cracks must not be of a converging nature.

(g) Cracks in outer surface of outer shroud are acceptable up to three inches maximum (Index 9, Figure 606). Cracks in weld around outer shroud brace (tea cup) are acceptable up to one inch maximum. See Index 7, Figure 606. A crack which extends from tea cup is acceptable if total length is less than three inches and length of crack around tea cup is less than one inch. These cracks are not to be of a converging nature.

(h) Cracks in weld bead at vane covers and/or shroud to vane (Index 8, Figure 606) are acceptable up to three inches maximum.

(i) Cracks in weld bead around various bosses in outer shroud (Index 10, Figure 606) are acceptable up to 180 degrees around boss leg.

(j) Cracks progressing into fin (Index 11, Figure 604) are not acceptable. These cracks must be weld repaired.

(k) Cracks are acceptable up to three inches long if wholly contained in shroud skin. See Index 12, Figure 605. A maximum of three cracks up to three inches long in any 90 degree sector are acceptable provided there is no convergence of cracks.

(5a) Inlet case vane - Mylar Tape Repair. Cracks in vane skin (Index 1, 3, 6, Figure 604, 605) up to five inches in length and which are not of a converging nature, are permissible provided a temporary repair using Mylar tape is incorporated using following procedures.

(a) Stop drilling both ends of crack.

NOTE: Exercise extreme care on vanes incorporating oil tubes.

(b) Clean area to be taped by scrubbing with stiff bristle brush using acetone or methyl ethyl ketone.

(c) Wipe dry with clean cloth to remove all residue.

(d) Wrap area of crack with Mylar tape but do not overlap tape.

NOTE: Mylar tape is available from Bordon Chemical Co., Mystic Tape Division, Northfield, IL 60093 or Markem Machine Co., 150 Congress St., Keene, NH.

ENGINE - INSPECTION/CHECK

(e) Monitor crack progression every 10 aircraft hours.

NOTE: An inlet case with this repair may be continued in service until aircraft returns to a maintenance base capable of making permanent repairs or for a period of 50 aircraft hours, whichever first occurs.

(5b) Inlet case rear flange bolt hole threads. Check rear outer flange for stripped attaching bolt hole threads. Repair stripped threads per Section 72-0, Engine - Approved Repair.

(5c) Inlet guide vanes incorporating heat sensitive paint. To provide a method of detecting failed anti-icing regulators, selected vanes have been spot painted with heat sensitive paint. Initial color of paint is white.

(a) Inspect painted vanes. An ivory color indicates anti-icing system operating at approximately 302°F (150°C).

(b) Painted vanes with a yellow color indicates anti-icing system operating at approximately 347°F (175°C).

(c) Failed anti-icing regulators result in elevated inlet guide vane temperatures which can be detrimental to life of vane filler material. Under normal operating conditions, inlet guide vane temperature should not exceed 302°F (150°C) during anti-icing system use. The existance of a yellow color suggests a malfunction of regulator vane and should be tagged for inspection, repair or possible replacement.

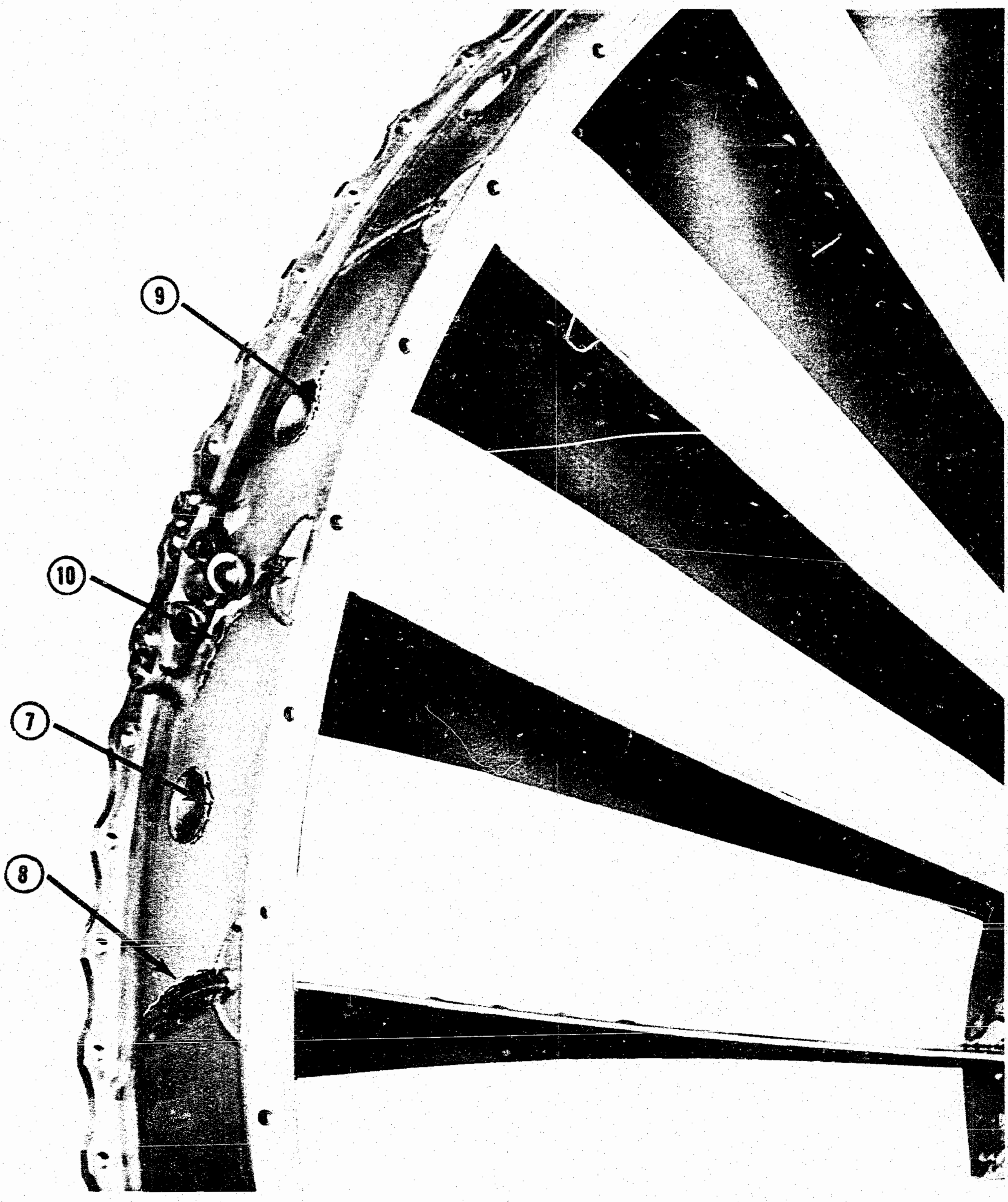
(6) First Stage Fan Blade Shift (Loose Lock).

NOTE: This procedure is applicable to "bat wing" type blade locks PN 512978 and 596216 only. PN 430242 and 478179 locks should no longer be used. See SB 1076, 3755.

(a) Blades found shifted forward up to 0.250 inch may be continued in service for an additional 50 hours provided that existing on wing inspection/repair criteria is satisfied and blade locks can be rebent to provide acceptable restraint.

(b) Blades found shifted forward in excess of 0.250 inch must be removed from service immediately.

(c) The affected and adjacent blades/hub blade slots in rotors in which forward blade movement has occurred should be visually and fluorescent inspected and repaired to overhaul manual requirements prior to return to service.



Inlet Case Crack Limits

Figure 606

(7) First Stage Fan Blade On Wing Repair And Flyback Limits

(a) First stage fan blades which have foreign object damage in excess of inspection and repair limits shown in Figure 601 may be continued in service, provided repair indicated in Figure 607 has been performed.

NOTE: Refer to Approved Repair section for repair procedure.

(b) Inspect repaired areas with dye-check or portable fluorescent penetrant. No cracks, tears, or sharp bottomed nicks are permitted after repair.

(c) Do not repair more than a total of 6 blades per rotor to any cut or combination of cuts in Figure 607. Reworked blades may be adjacent or scattered throughout the rotor assembly. However, any individual blade incorporating the dimensions of either the 25 or 150 hour cut-back will restrict the time on that rotor to 25 or 150 hours as applicable.

(d) After any FOD, either repaired or non-repaired, all limits are valid only if continued use of damaged blades does not cause excessive imbalance or vibration during engine operation.

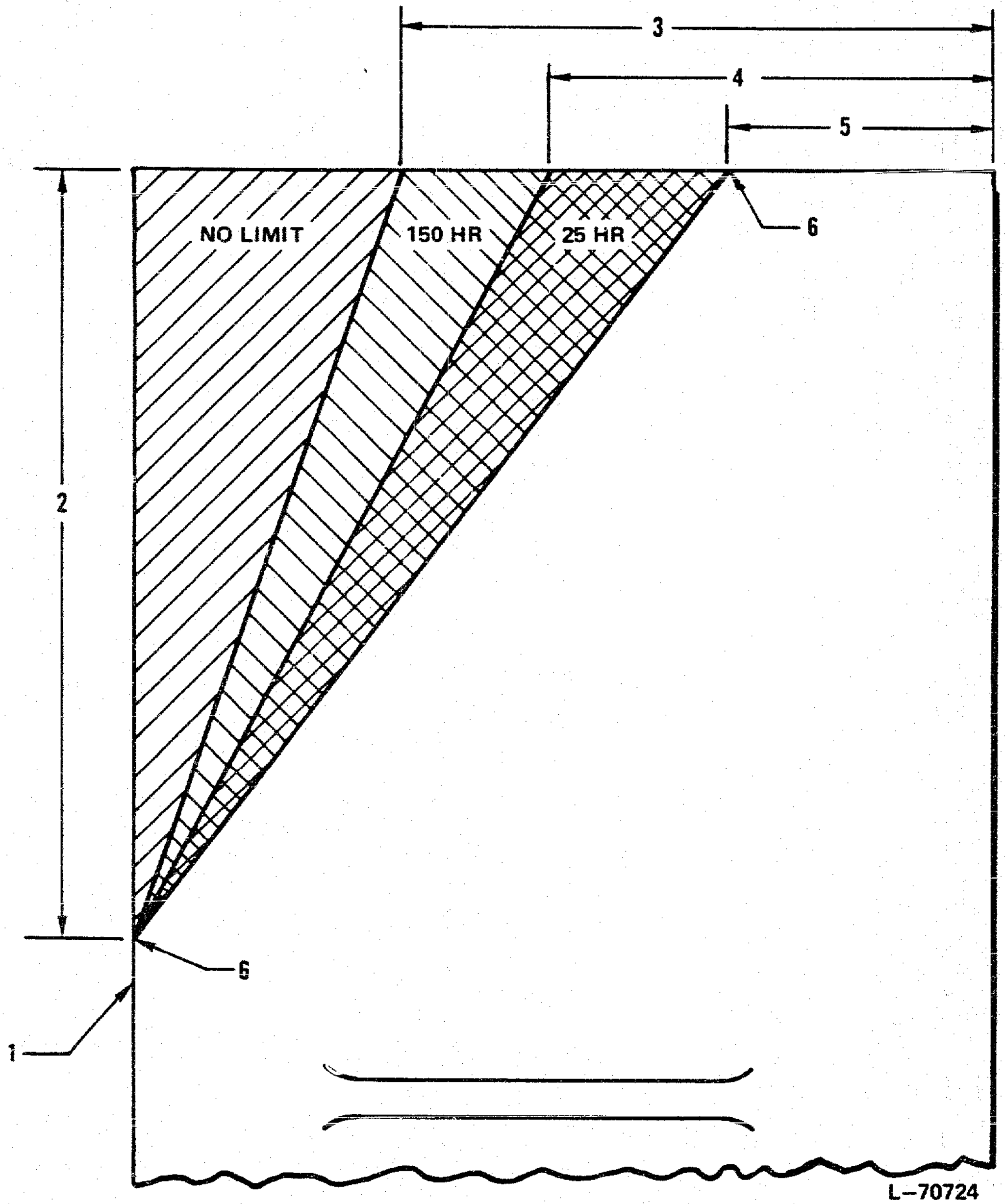
(e) Shingled blades (blades whose mid-span shrouds have overlapped due to foreign object ingestion) must be unshingled and may be continued in service for maximum of 20 hours if following conditions are met:

1 Shingled blades must be unshingled without further damage.

2 Visual inspection must confirm that mid-span shroud of shingled blade has not hit airfoil of adjacent blade or radius between airfoil and mid-span shroud of adjacent blade. Blades showing evidence of having been hit in this manner must be removed from service before further flight.

3 After 20 hour limit, shingled compressor blades should be removed and inspected for damage, cracks and airfoil displacement (bow). Refer to Overhaul Manual.

ENGINE - INSPECTION/CHECK



1. Leading Edge
2. 4.50 Inches
3. 3.35 Inches
4. 2.50 Inches
5. 1.50 Inches
6. Smooth Blend

First Stage Fan Blade On Wing Repair
And Flyback Limits
Figure 607

ENGINE - INSPECTION/CHECK

(7a) Ultrasonic inspect first stage fan blades for cracks in convex airfoil-to-platform fillet radius near trailing edge per Alert Service Bulletin 5136 and time cycle given in Section V, Time Limits of overhaul manual.

(8) Turbine Blade Shroud Notch Wear Check (Broomstick Check).

CAUTION: SINCE PN 434104 BLADES COULD BECOME DISENGAGED BY HANDLING AND LOOSENESS CHECK, VISUALLY INSPECT BLADES WITH STRONG LIGHT TO ENSURE ENGAGEMENT OF SHROUD NOTCHES. RE-ENGAGE BLADES.

(a) Check for blade looseness at intervals compatible with periodic aircraft checks. Excessive shroud notch wear can result in blade looseness and failure.

(b) Attach short length of rubber hose to a wood pole or broomstick of sufficient length to reach fourth stage turbine blades through exhaust nozzle.

CAUTION: TO REDUCE POSSIBILITY OF BLADE SHROUD NOTCH DISENGAGEMENT, DO NOT USE POLE OR HOSE ATTACHMENT TO ROTATE TURBINE.

(c) When engine is cold, press short length of hose lightly against turbine blades and rotate front compressor by hand in normal direction of rotation to produce strumming action of hose against blades.

(d) If blade rattling is noticed, blade looseness is evident and fourth stage turbine disk and blade assembly must be removed. Replace disk and blade assembly with an assembly containing blades with tight notches.

(9) Inspect and recondition fuel manifolds and nozzles per Section 73-5-1, Accessory Component Overhaul Manual.

(10) First Stage Fan Blade Bow Check

(a) Place a straight edge on convex surface of airfoil above midspan shroud approximately at center of airfoil chord and perpendicular to blade root center plane.

(b) Maximum bow is then defined as no more than 1/8 inch gap between blade surface and straight edge at any point.

(c) No appreciable bow is allowed for second stage fan blade.

2. Seventh Stage Disk - Front Compressor Rear Hub - Crack Inspection (JT3D-1,-3,-3B)

A. Inspection Requirements

(1) All engines incorporating thin web seventh stage disk and thin flange front compressor rear hubs, must be inspected with specified equipment per procedures outlined in this section and with Table I.

(a) After rework per SB 1671 for disk and SB 1671R2 or subsequent for hub, follow on eddy-current or wink zyglo inspection for JT3D-1 engines is 8000 cycles for disk and hub. Inspection intervals for JT3D-3,-3B engines are 4000 cycles for disk and 3000 cycles for hub. These follow-on inspections are good only once. Subsequent repetitive on-the-wing or bench inspection must be performed every 2000 cycles for JT3D-1 and 1000 cycles for JT3D-3,-3B.

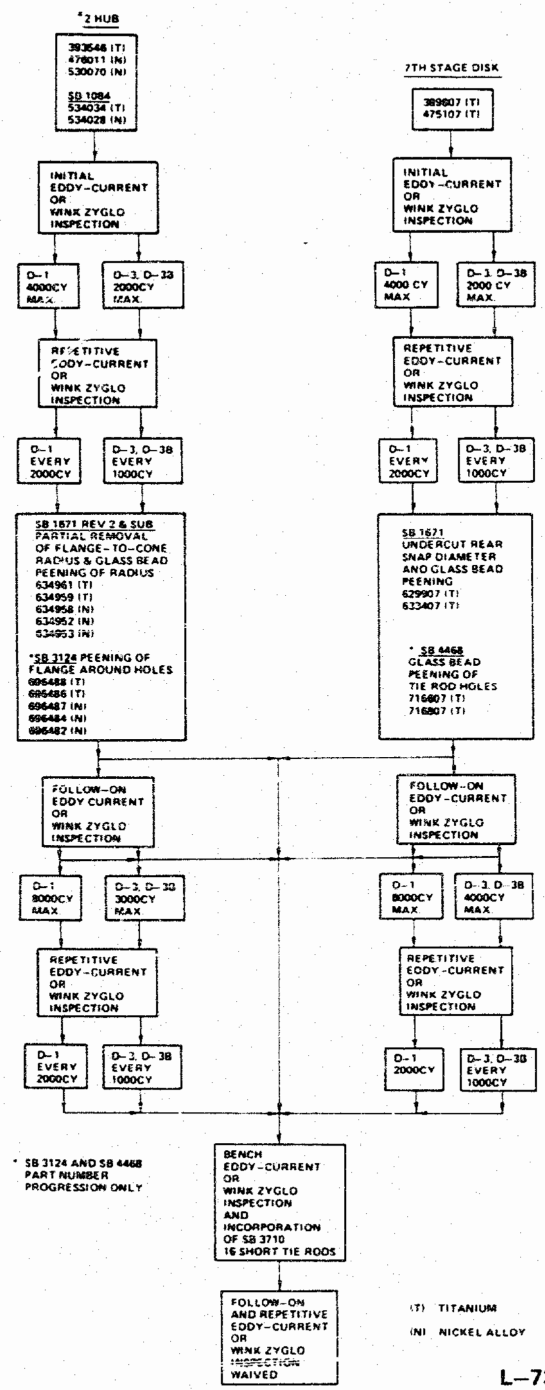
(b) After rework per SB 1671 for disk and SB 1671R2 or subsequent for hub, bench eddy-current or wink zyglo inspection, and incorporation of SB 3710 (16 short tierods), follow-on and repetitive inspections are waived.

(2) All engines incorporating thick web disks, PN 639307, 716707, 719407, 725907 and thick flange hubs, PN 635498 and 753528 are exempt from this inspection.

(3) Inspection will be accomplished with use of eddy-current and access to areas to be inspected may be gained by removing front accessory case cover, number one bearing inner race retaining nut (if necessary) and front accessory drivegear.

NOTE: Engines which incorporate front accessory drivegear held by retaining ring (Reference SB 3701) do not require removal of inner race retaining nut. Compress retaining ring and remove gear to gain access to inside at rotor.

ENGINE - INSPECTION/CHECK



L-73565

Table I

B. Equipment Required

(1) Magnaflux ED 500 series instrument or equivalent.

(2) PWA 30458, 7th stage compressor disk inspection tool.

(3) PWA 30518 or PWA 30471, front compressor rear hub inspection tool.

C. Equipment Operation Procedures for No. 2 Hub.

(1) For all engines except JT3D-1-MC7, connect PWA 30518 Probe to instrument. When inspecting JT3D-1-MC7 engines, use PWA 30471 Probe. Turn instrument on and allow 15 minutes to warm up.

NOTE: Remove covering tape from end of probe prior to use in testing.

(2) Set FREQUENCY control to 0, the highest frequency. Turn SENSITIVITY control to medium. Turn BALANCE control as required to obtain on scale reading.

(3) Using a portable light, locate a lightening/counterweight hole (outer holes in conical section) of hub which is located near or at bottom of hub. See Figure 608.

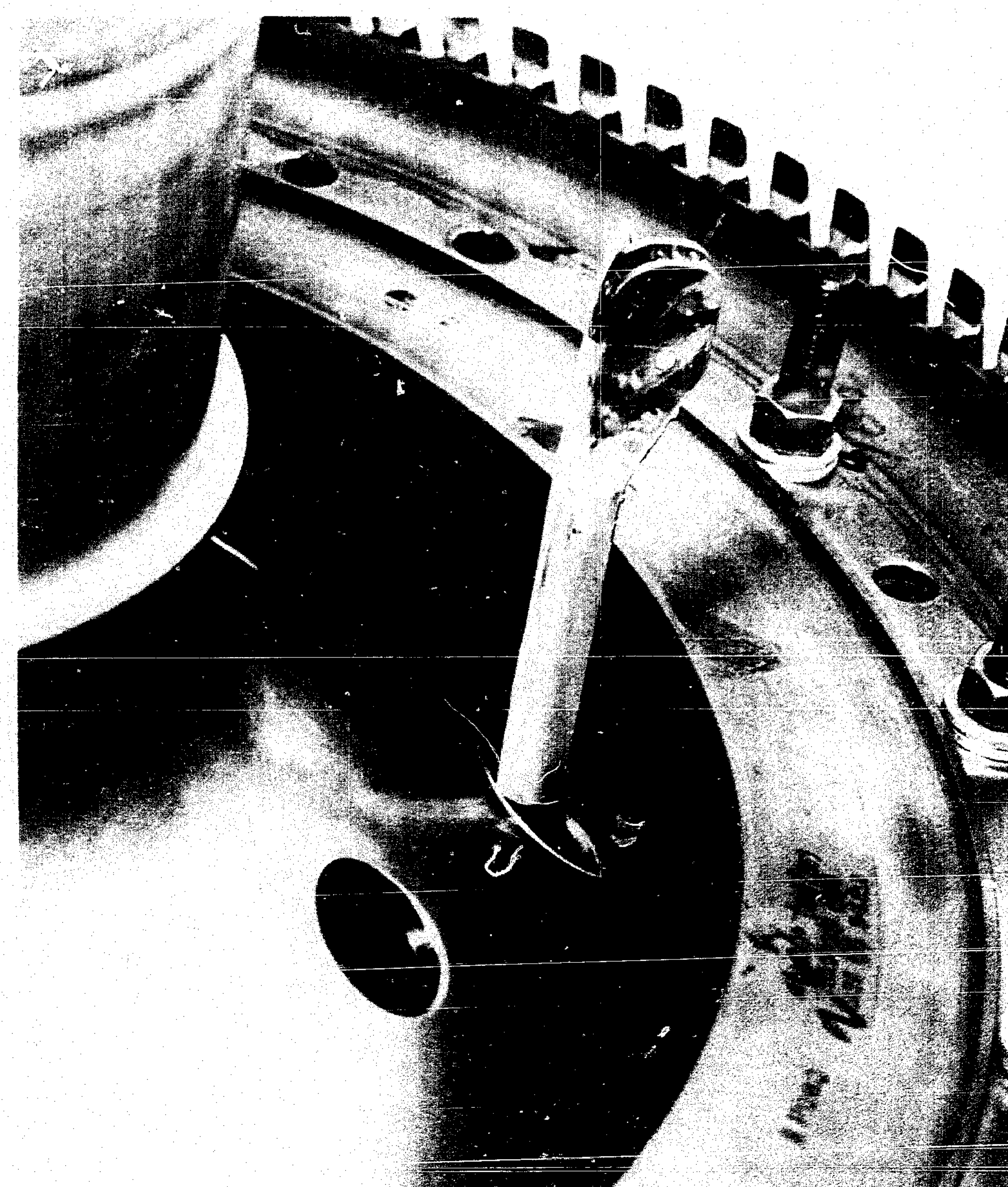
CAUTION: EXERCISE EXTREME CAUTION TO PRECLUDE DAMAGE TO INSPECTION EQUIPMENT.

(4) Insert inspection tool through bore of No. 1 hub and lightening/counterweight hole.

(5) Pull trigger on tool handle to release eddy current probe head enough to rest probe head against conical section of rear side of hub. There should be no pressure on trigger once probe head has been positioned against hub.

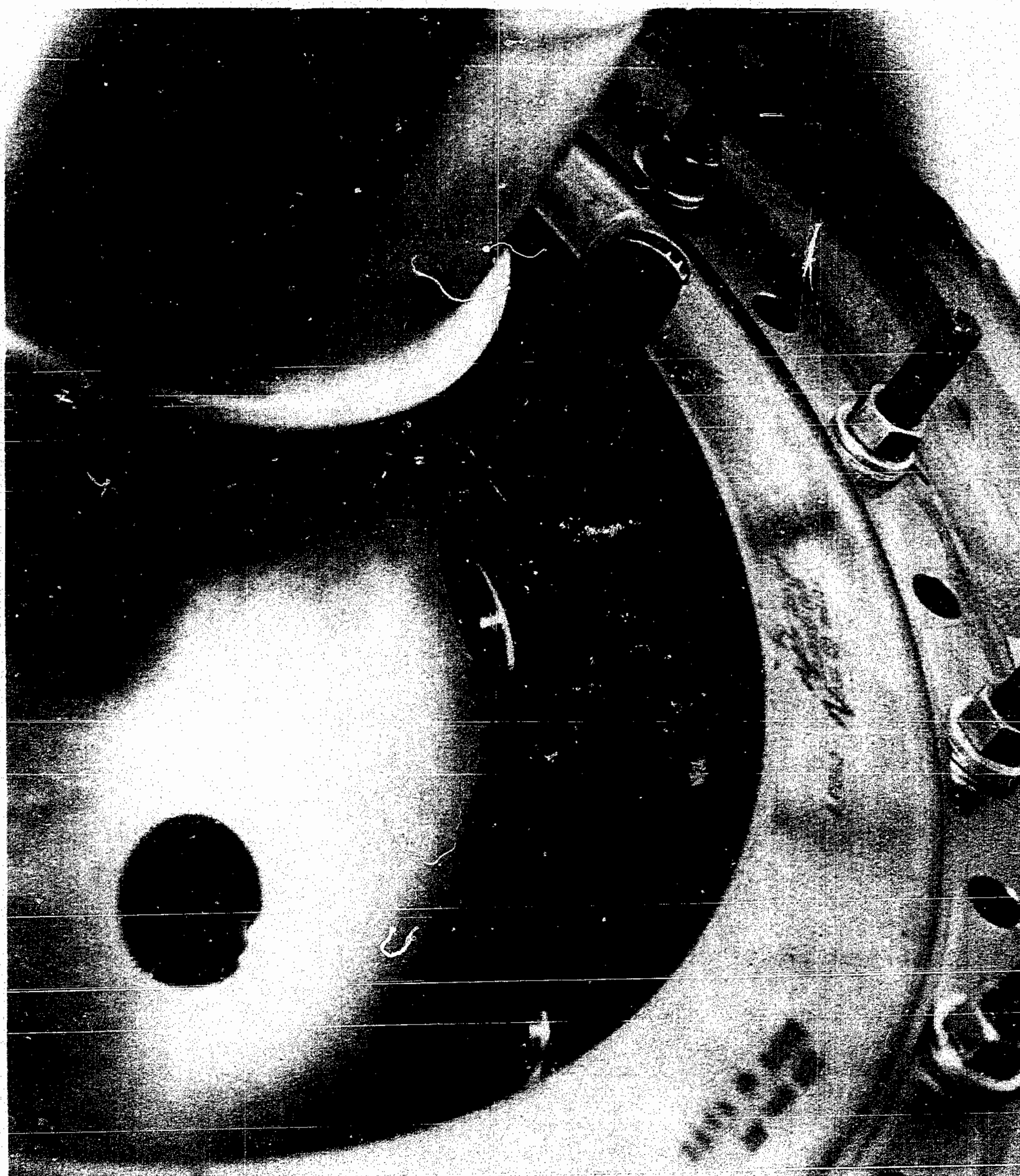
(6) Cautiously extract tool toward front of engine until probe head has positioned itself in hub flange-bell-blend radius which is inboard of No. 7 - No. 8 rotor spacer flange ID. See Figure 609.

(7) While observing micro-ampere meter, rotote tool and scan radius in both directions. Meter will indicate large deflections toward zero as probe passes tierod holes. These deflections may be standardized to -100 units by careful frequency selection.



Probe Head Following Conical
Section of Hub (Rear Side)

Figure 608



Probe Head in Small Radius
of Hub (Rear Side)

(8) Select proper frequency.

(a) Turn "LIFTOFF" control to 240 and repeat step (7).

(b) Continue adjusting "LIFTOFF" and "BALANCE" controls until a point is reached where tierod bolt proximity causes down scale meter deflection of 100 units.

(c) Release forward pressure on tool and carefully push toward rear of engine until probe head assumes a horizontal position, and extract from lightening/counterweight hole.

(d) Extract tool from inside of engine through bore of No. 1 hub.

(e) Crack deflection definition of +150 units may be observed using a simulated cracked test piece.

(f) Instrument is now ready for inspection of hub radius.

D. Inspection of Front Compressor Rear Hub.

(1) Repeat step C(3), except mark first hole that is being used for inspection with Magic Marker, to aid in determining starting point of inspection. Also repeat steps C(4), C(5) and C(6).

(2) Rotate probe slowly from one extreme to another and observe the meter for up scale deflection. Entire travel of probe head is approximately four inches. Indication of a crack will be noted on the meter up-scale when 100 micro-amperes or more are observed.

(3) Repeat steps C(8)(d) and C(8)(e).

(4) Repeat steps C(3), C(4), C(5), C(6) and C(8)(d) and inspect entire circumference of hub flange-bell-radius through remaining five lightening/counterweight holes.

(5) Crack indication(s) will require removal of engine from aircraft and disassembly to confirm indication(s).

E. Equipment Required (Alternate)

NOTE: Eddy Current Inspection of Front Compressor Rear Hub Incorporating Ideal Specialty Company P/N 6113 Probe Tip or P/N 6123 Arm and Head Assembly.

(1) Magnaflux ED 520 series instrument.

(2) PWA 30518 Inspection Tool or equivalent.

F. Equipment Operating Procedures

(1) Connect Inspection tool to instrument. Turn instrument ON and allow to warm up for minimum of 15 minutes.

(2) Set FREQUENCY CONTROL to position 1000, the lowest frequency. Turn SENSITIVITY control to Hi.

(3) Place probe on hub crack standard and rotate Balance Control to bring meter to mid-scale.

(4) Slowly pass probe over crack and note meter deflection.

(5) Turn FREQUENCY CONTROL to lower position and repeat steps 3 and 4.

(6) Continue turning FREQUENCY CONTROL and checking hub crack standard until a position is found which gives maximum meter deflection in an up-scale direction. This should occur at frequency setting of approximately 600-800. Meter deflection should be at least 100 micro-amperes in the up-scale direction.

(7) If no hub crack standard available.

(a) Starting at 1000 frequency setting, lift off compensate on hub to be inspected.

(b) Remove probe from engine and place on PWA crack standard. Meter deflection should be at least 100 micro-amperes in the up-scale direction.

(c) If standard crack does not produce 100 micro-amperes, a hub standard must be obtained for system calibration.

(8) Using external lighting (flashlight, drop-cord, etc.) locate a lightening/counterweight hole (outer holes in conical section) of hub which is located near or at the bottom of hub.

(9) Insert inspection tool through bore of number 1 hub and lightening/counterweight hole. Extreme caution should be exercised to preclude damage to inspection equipment.

(10) Pull trigger on tool handle to release eddy current probe head enough to rest probe head against conical section of rear side of hub. There should be no pressure on trigger once probe head has been positioned against hub.

(11) Cautiously extract tool toward front of engine until probe head has positioned itself in the hub flange-bell-blend radius which is inboard of No. 7 - No. 8 rotor spacer flange ID.

(12) Rotate "BALANCE CONTROL" to bring meter to mid-scale.

(13) The instrument is now ready for inspection of hub radius.

G. Accomplishment Instructions

(1) Repeat Step F8, except mark first hole that is being used for inspection with magic marker, to aid in determining starting point of inspection. Also repeat steps F9, F10 and F11.

(2) Rotate probe slowly from one extreme to another and observe the meter for up-scale deflection. Entire travel of probe head is approximately 4 inches. Indication of a crack will be noted on the meter up-scale when 50 micro-ampers or more are observed.

(3) Release forward pressure on tool and carefully push toward rear of engine until probe head assumes a horizontal position, and extract from lightening/counterweight hole.

(4) Inspect entire circumference of hub flange-bell-radius through remaining five (5) lightening/counterweight holes.

(5) Crack indication(s) will require removal of engine from aircraft and disassembly to confirm indication(s).

H. Equipment Operating Procedures for Seventh Stage Disk

(1) Connect PWA 30458 Inspection Tool to instrument. Turn the instrument "ON" and allow minimum warm up of 15 minutes.

(2) Follow instrument manufacturer's instructions for "FREQUENCY" and "LIFTOFF" adjustments.

(3) Crack deflection definition may be observed using simulated cracked test piece.

(4) Insert inspection tool through bore of No. 1 hub.

(5) Locate and place probe head on bore of disk and turn "BALANCE" control to give midscale meter indication.

(6) The instrument is ready for inspection of front face of seventh stage disk.

I. Inspection of Seventh Stage Disk

(1) With probe head resting on bore of disk, slowly traverse web area with probe and observe meter. Engine may be rotated for this inspection. Caution should be exercised to preclude probe head jumping disk bore.

(2) Indication of a crack will be noted on meter scale when a deflection of meter from its mid-scale position is observed.

(3) Crack indication(s) will require removal of engine from aircraft and disassembly to confirm indications.

2A. Seventh Stage Disk - Front Compressor Rear Hub - Crack Inspection (Alternate - Eddy Current)

A. Equipment

(1) One Forster Defectometer 2.164 or 2.154 or one Magnaflux ED 1500 Eddy Current Generator.

(2) Sensitivity setting blocks.

(a) For PWA 1003 material hardware.

(b) For AMS 4928 material hardware.

(c) Sensitivity blocks consist of a 2.0 x 2.0 x 0.040 inch thick section of appropriate material into which has been electrodischarge machined a slot centrally located in 2.0 x 2.0 inch face measuring 0.500 inch long x 0.010 inch wide x 0.018 - 0.022 inch deep.

(3) Eddy current probes.

(a) Seventh stage disk probe (seventh stage disk front).

ENGINE - INSPECTION/CHECK

(b) Front compressor rear hub probe (seventh stage disk rear).

NOTE: Probes are available from Dr. Forster, 7410 Reulinger, Grathwolster, West Germany.

B. Setup Procedure

(1) Turn instrument on and allow sufficient warm up time.

(2) Connect appropriate probe to instrument.

(3) Using "Fe POSITION", liftoff compensate probe on sound portion of appropriate sensitivity setting block.

(4) Adjust "SENSITIVITY" to obtain convenient meter deflection between 1 and 5 units when "slot" portion of standard is traversed.

C. Inspection Procedure For Seventh Stage Disk

(1) Insert probe into engine.

NOTE: Complete instructions as to handling and mechanical adjustment of probe are included in manufacturers manual.

(2) Make further adjustment to liftoff compensation if necessary on at least two locations on disk to be sure compensation was adjusted on sound portion of disk.

(3) Slowly revolve probe (or motor engine) while monitoring meter for upscale and return meter movements indicative of presence of crack.

(4) Indications equal to or exceeding amplitude obtained on sensitivity setting block will require removal of engine and disassembly to confirm crack indications. Indications of lesser amplitude than obtained on sensitivity setting block are acceptable.

D. Inspection Procedure For Front Compressor Rear Hub

(1) Insert probe through outer lightening hole (6 o'clock position) to rear hub.

NOTE: Complete instructions as to handling and mechanical adjustment of probe are included in manufacturers manual.

(2) Make further adjustment to liftoff compensation if necessary on at least two locations on hub to be sure compensation was adjusted on sound portion of hub.

(3) Rotate probe slowly from one extreme to the other while monitoring meter for upscale and return meter movements indicative of presence of crack.

(4) Repeat substep (3) at each of outer lightening hole locations.

(5) Indications equal to or exceeding amplitude obtained on sensitivity setting block will require removal of engine and disassembly to confirm crack indications. Indications of lesser amplitude than obtained on sensitivity setting block are acceptable.

2.B. Fan Case - Determination Of Repair Band Material - Inspection (Eddy-Current)

A. Equipment

(1) One Defectometer 2.164 or 2.154.

(2) One Forster Pencil Probe FE/AUS 2.154 - 351.

(3) Test samples.

(a) Hastelloy "X", 2.0 x 0.049 inch thick.

(b) AMS 5504, 2.0 x 0.049 inch thick.

B. Set Up Procedure

(1) Set Deflectormeter on FE position.

(2) Set sensitivity control to minimum or full CCW position.

(3) Turn on and allow instrument to warm up.

(4) Lift off compensate on Hastelloy "X" test sample.

(5) Place probe on AMS 5504 test sample. Needle should deflect to full scale on saturation.

C. Inspection Procedure

(1) Insert probe through inlet case, fan blades, and first stage vanes and place on band approximately half way across.

(2) If needle deflects to full scale on saturation, material is AMS 5504.

(3) If needle remains at zero or less than one, material is Hastelloy "X".

3. Combustion Chamber Lug Wear Pad - On Wing Radiography Inspection.

WARNING: ISOTOPE RADIOGRAPHY MUST BE PERFORMED BY QUALIFIED PERSONNEL AND ALL APPROPRIATE SAFETY PRECAUTIONS MUST BE OBSERVED.

NOTE: Inspection procedure for cases with wear pads. Following cases do not have wear pads unless they were reoperated to Service SB 2384; PN 433011, 488961, 617071.

A. Move aircraft to remote area that affords protection from radio activity.

B. Remove front accessory drive support and front accessory drive main gear per Section 72-00, Disassembly.

C. Locally fabricate a tube to accept Iridium-192, Type 100c Source. Insert a cap in inner end of tube to provide a locating stop for source when it is in position.

D. Locally fabricate tooling necessary to support tube in position.

E. Insert source guide tube into shaft of engine such that in exposed position source will be 84.1875 inches from front face of compressor inlet cone support assembly. See Figure 610.

NOTE: Exact source positioning is needed to obtain adequate radiographs for accurate wear determination. See Figures 611 a, b.

To ensure that correct source positioning has been achieved, a test shot (800 curie - minute exposure) with a fast film such as Agfa Gaevert D-10 or equivalent is recommended. Source is correctly positioned if inner surface of radiographic image of "V" shaped contoured indenture, Figure 612, is between 0.216 inch and 0.256 inch (5.5 to 6.5 MM) from "H" flange, Figure 611 b.

F. Tape 4 inch by 7 inch Agfa Gaevert D-4 lead pack film onto the engine case at the eight positions shown in Figure 613. (Kodak "M" film may be used if D-4 is not available.)

NOTE: Equivalent type film may be used when exposures are adjusted to give same results.

(1) Number films one through eight clockwise from rear starting at twelve o'clock position. Mark engine number on No. 1 film.

G. Obtain following gamma-ray projector equipment or equivalent.

(1) Technical Operations Model 529 Gamma Ray Projector Control.

(2) Technical Operations Model 533 Shielded Container.

(3) Flexible Guide Tube.

NOTE: Technical Operations Inc., Burlington, Mass. have indicated they would be willing to furnish equipment required.

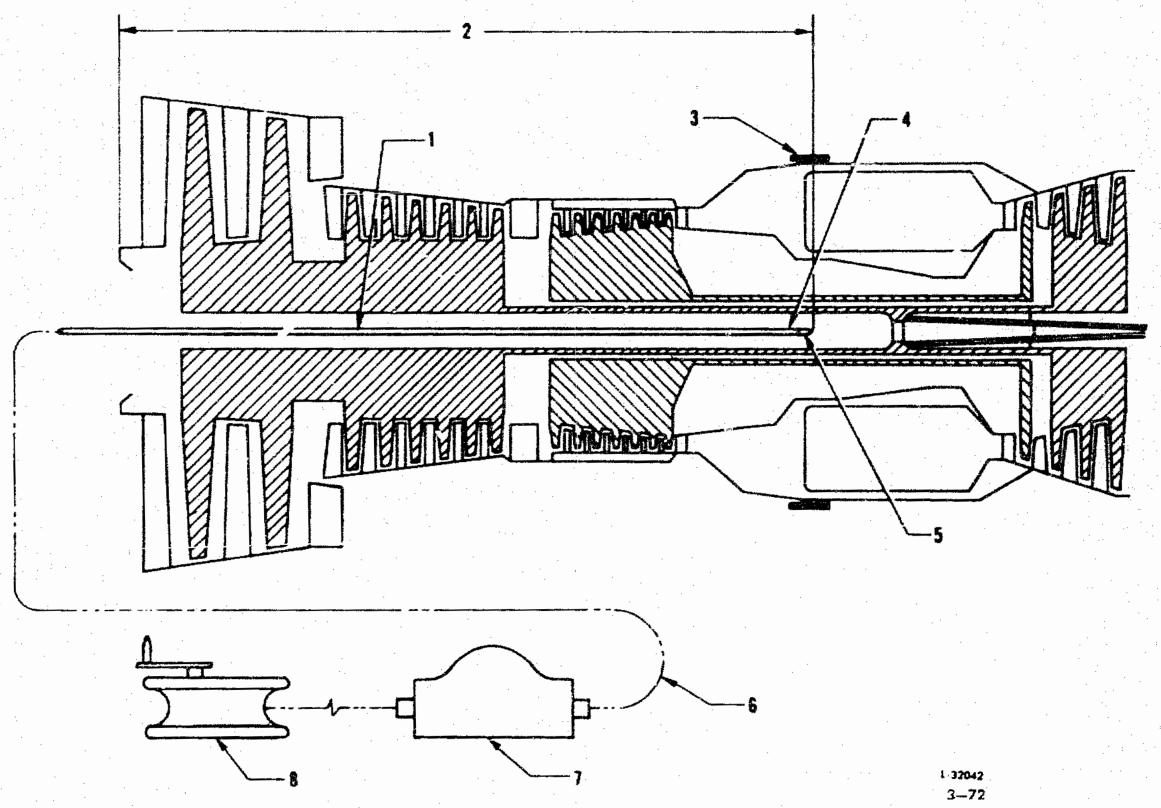
H. Expose film for 3000 curie-minutes (increase exposure by a factor of 1.33 if "M" film is used).

NOTE: Curie-minutes are determined from actual exposure in minutes multiplied by power source-type 100C power rated at time of exposure.

I. Develope film per manufacturers recommendations.

J. Interpret radiographs using a high intensity light box, film density approximately 4.0.

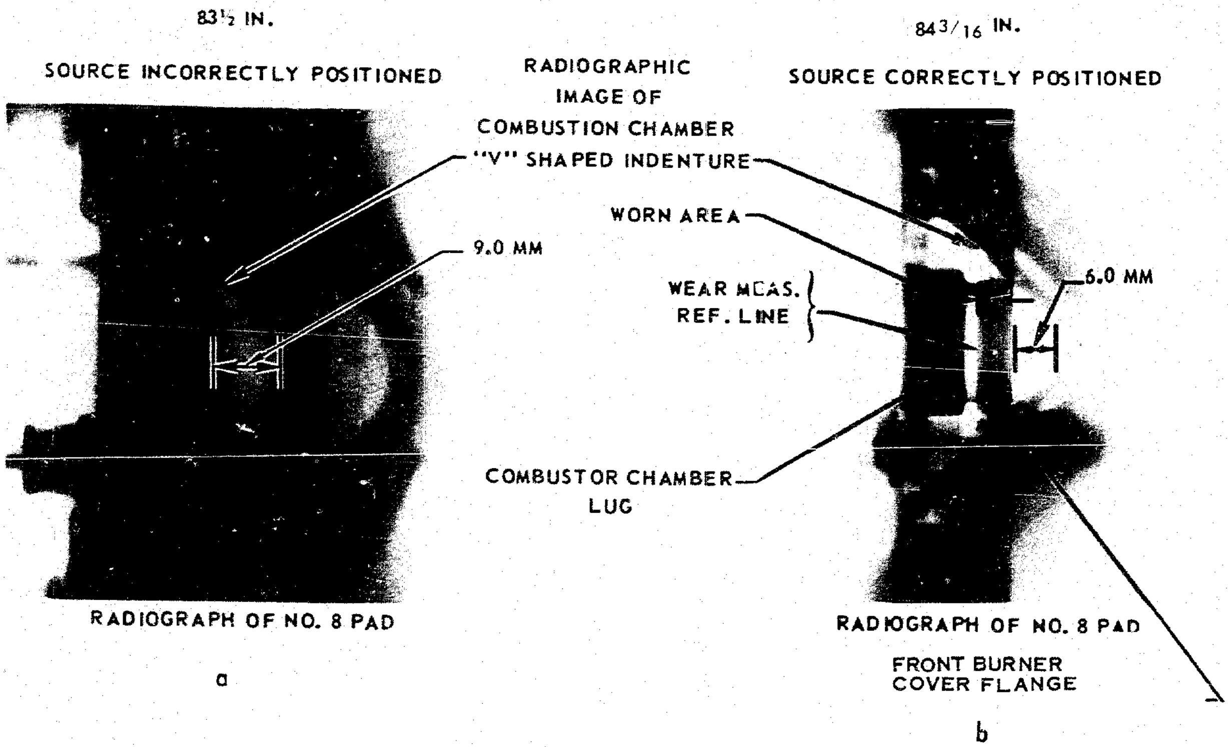
NOTE: Wear to a maximum depth of 0.015 inch will be allowed on pad at interim inspection periods with pad replacement required at next hot section.



1. Capped Tube (Source Travels Inside).
2. 84.1875 Inches To Exposed Source.
3. Agfa Gaevert D 4 Lead Pack Film (4 x 7 Inches), 8 Sheets
4. Iridium-192 Source.
5. Cap
6. Flexible Guide Tube.
7. Shielded Container
8. Gamma Ray Projector Control.

Isotope Inspection Of Combustion
Chamber Lug Wear Pads

Figure 610



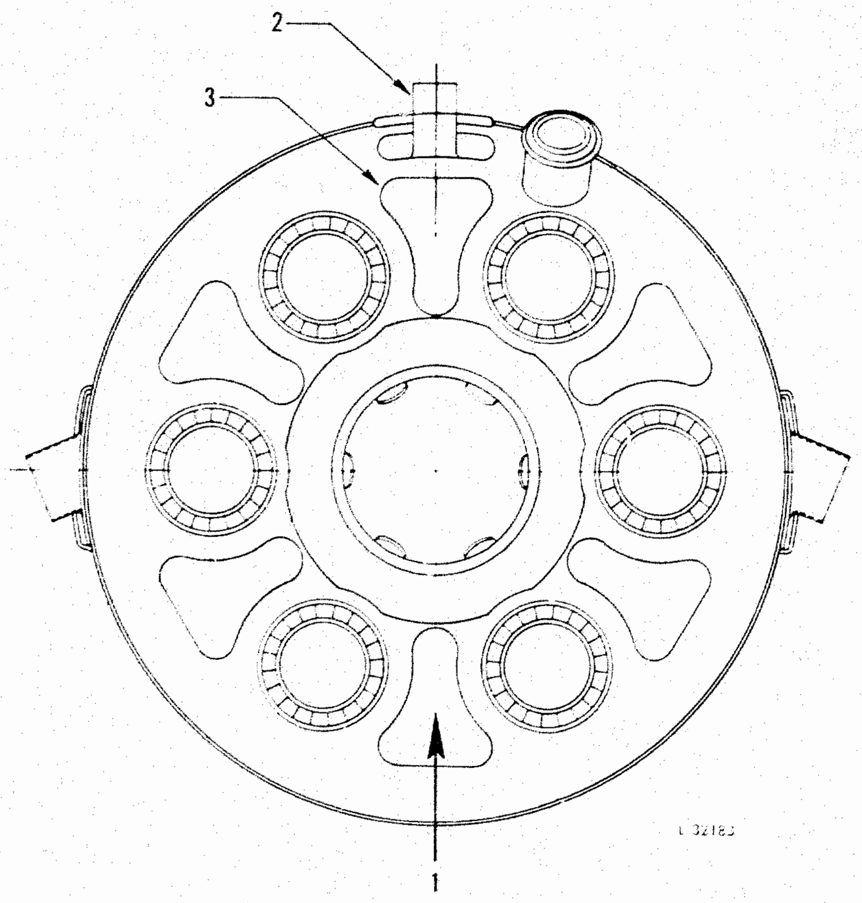
Radiographic Image Of Combustion Chamber
Figure 611

4. Combustion Chamber Weldments

A. General

(1) Cracks in combustion chamber surfaces are usually of stress relieving nature and, as such, are not serious in that the rate of growth decreases as the crack lengthens. Thermal stresses, in effect, relieve original stress condition. It is usually normal to observe repetitive occurrence of a given type of deterioration from chamber to chamber in a given engine.

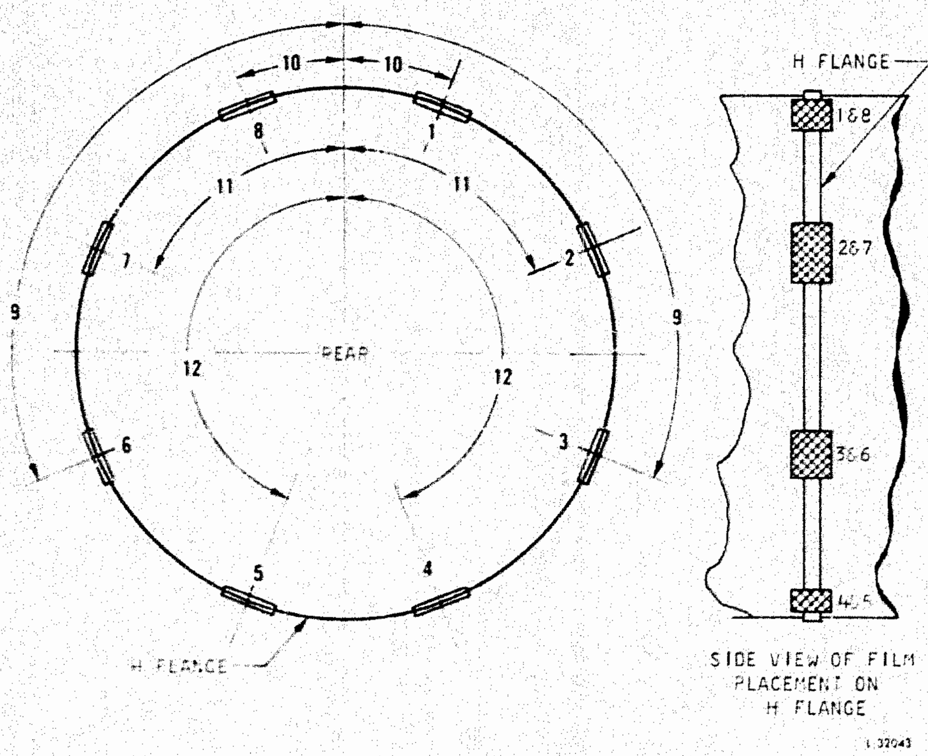
(2) To ensure consistency and to eliminate confusion in reports or inspection standards, use the established nomenclature for the various components of the combustion chambers as shown in Figures 614 and 615.



1. Source Projection
2. Combustion Chamber Lug
3. "V" Shaped Contoured Indenture.

Isotope Inspection Of Combustion Chamber Lug Wear Pad
Figure 612

ENGINE - INSPECTION/CHECK



1 Thru 8. Film Locations

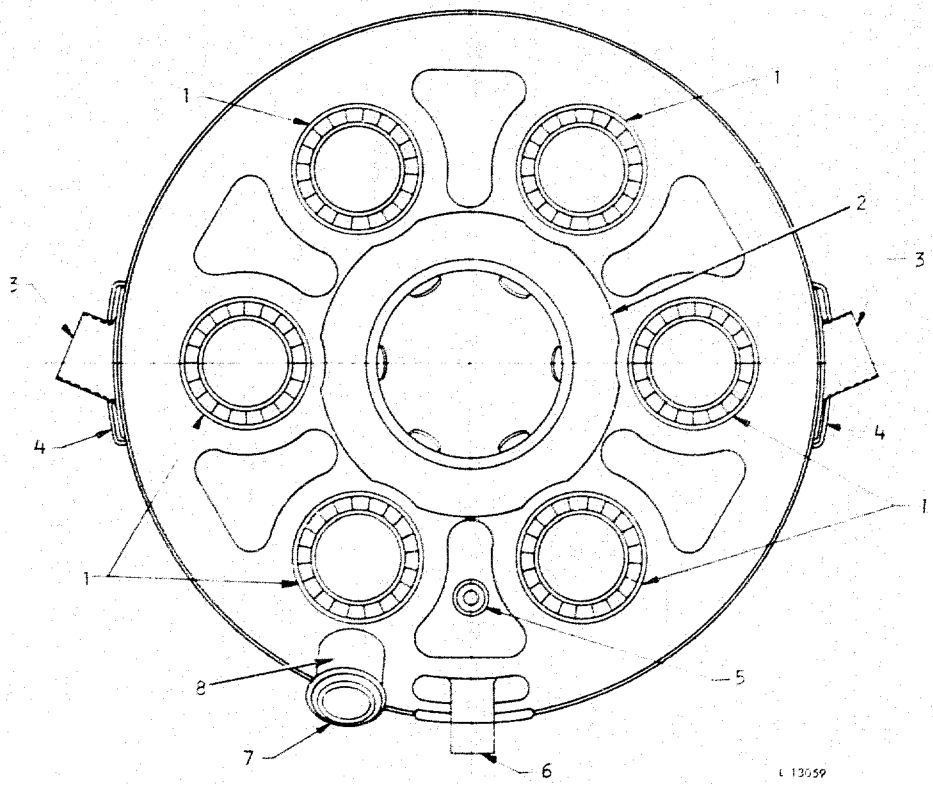
9. 39.5 Inches

10. 7.9 Inches

11. 23.7 Inches

12. 55.3 Inches

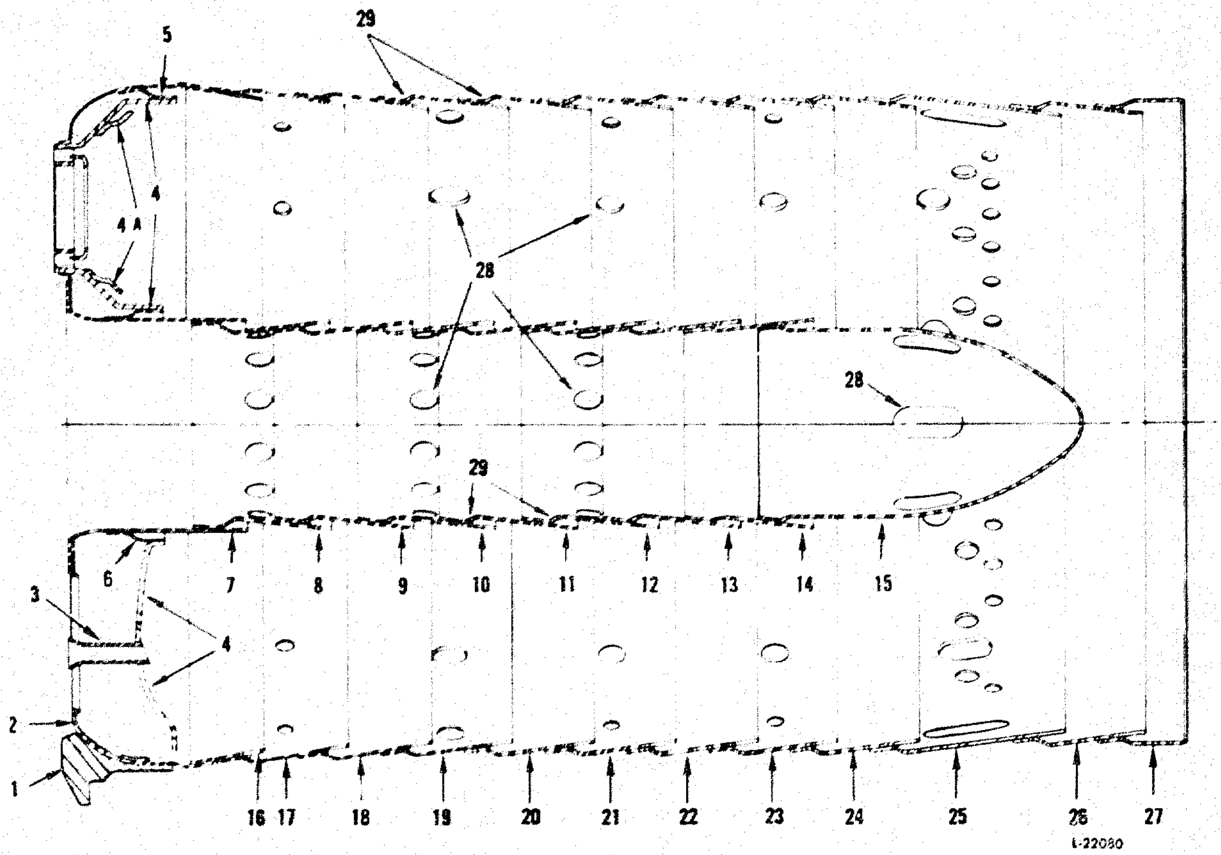
Film Locations For Isotope Inspection
Figure 613



1. Air Swirl Guide
2. Front End Inner Liner
3. Cross Over Tube
4. Heatshield
5. Burner Transfer Tube
6. Locating Lug
7. Igniter Plug Bushing
8. Igniter Plug Sleeve

Combustion Chamber Nomenclature

Figure 614



1.	Locating Lug	15.	Rear End Inner Liner
2.	Cover	16.	Front Outer Liner
3.	Burner Transfer Tube	17.	No. 1 Outer Liner
4.	Swirl Cup	18.	No. 2 Outer Liner
4A.	Baffle	19.	No. 3 Outer Liner
5.	Outer Brace	20.	No. 4 Outer Liner
6.	Inner Brace	21.	No. 5 Outer Liner
7.	Front End Inner Liner	22.	No. 6 Outer Liner
8.	No. 1 Inner Liner	23.	No. 7 Outer Liner
9.	No. 2 Inner Liner	24.	No. 8 Outer Liner
10.	No. 3 Inner Liner	25.	No. 9 Outer Liner
11.	No. 4 Inner Liner	26.	No. 10 Outer Liner
12.	No. 5 Inner Liner	27.	No. 11 Outer Liner
13.	No. 6 Inner Liner	28.	Combustion Air Holes
14.	No. 7 Inner Liner	29.	Cooling Air Holes

NOTE: Head assembly includes Index Nos. 1 through 6. Inner liner assembly includes Index Nos. 7 through 15. Outer liner assembly includes Index Nos. 16 through 27.

Combustion Chamber Nomenclature

Figure 615

(3) Figures 616 through 621 show various types of combustion chamber deterioration which may be found in chambers at time of inspection. The following paragraphs will call out the deteriorated areas and tell whether or not they can be repaired or replaced.

(4) Fluorescent penetrant inspect combustion chambers in accordance with SPOP 62.

NOTE: Particular attention should be given to all the seam weld joints in the inner and outer liner segments on both the inside and outside liner surfaces.

(5) All cracks found in the seam weld joints must be weld repaired.

B. Acceptable Areas Without Repair

(1) Buckling on the OD of the fuel nozzle swirl cup is acceptable without repair provided that no cracks extend from the buckled areas. See reference number 1, Figure 616.

(2) Burning of the louver inside the wall to the extent shown in reference number 1, Figure 621 is acceptable.

(3) Burning of the inner liners to the degree shown in reference numbers 2 and 4, Figure 618, is acceptable. Straighten any bent louver to provide 0.070 to 0.120 inch clearance between louver and liner segment ID. If the head is replaced, rotate the inner liner 90 degrees with respect to the outer liner when reassembling.

(4) No unrepaired cracks permissible in inner liner assembly. See Paragraph C.

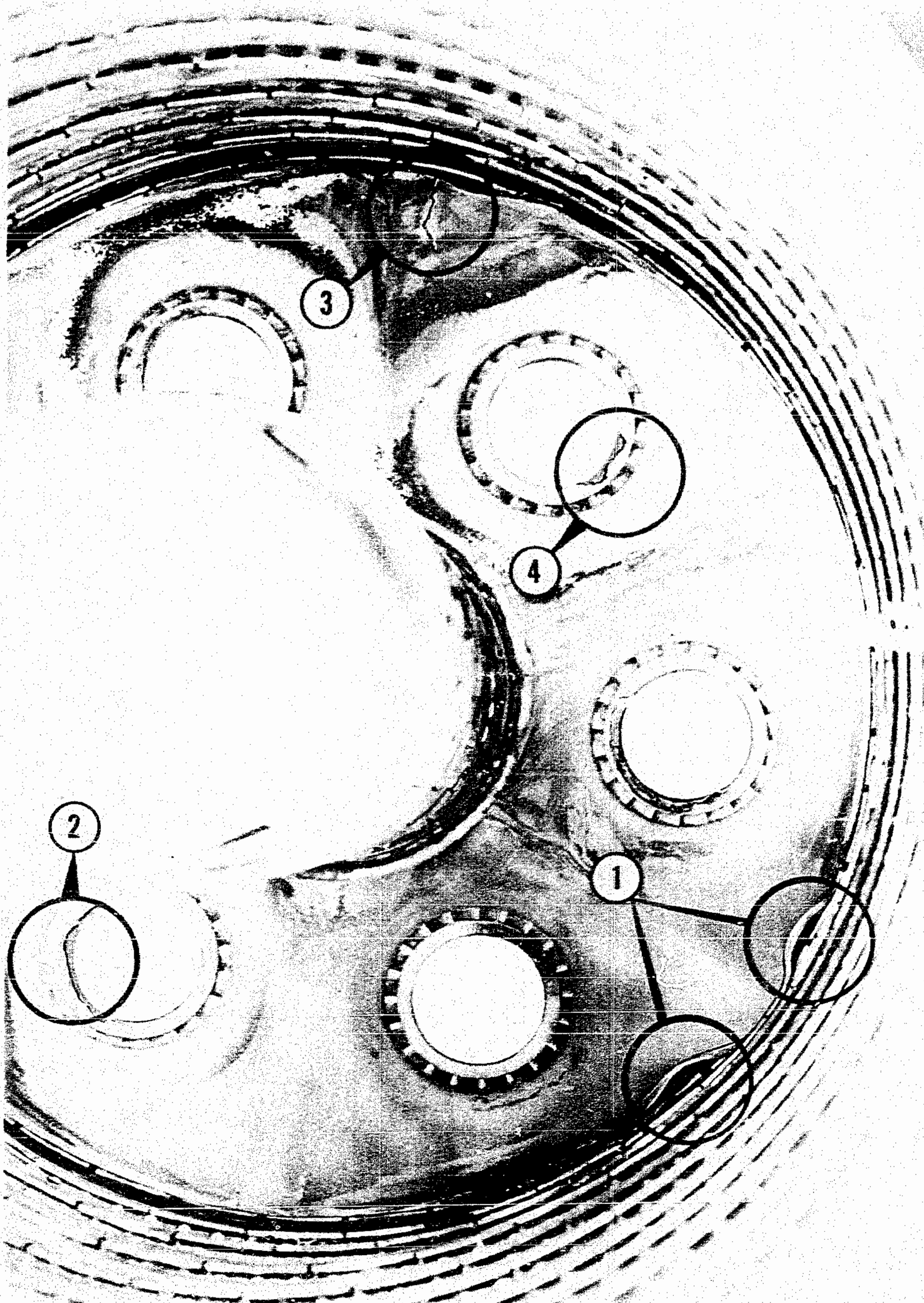
C. Acceptable Areas With Repair

(1) Cracks underneath the flame tubes are not acceptable. See reference number 1, Figure 619. Repair this condition by replacing the flame tube.

(2) Burning on the inside of the liners directly underneath the flame tubes as shown in reference number 3, Figure 620, is not acceptable and must be repaired by patching the outer liners and replacing the flame tube.

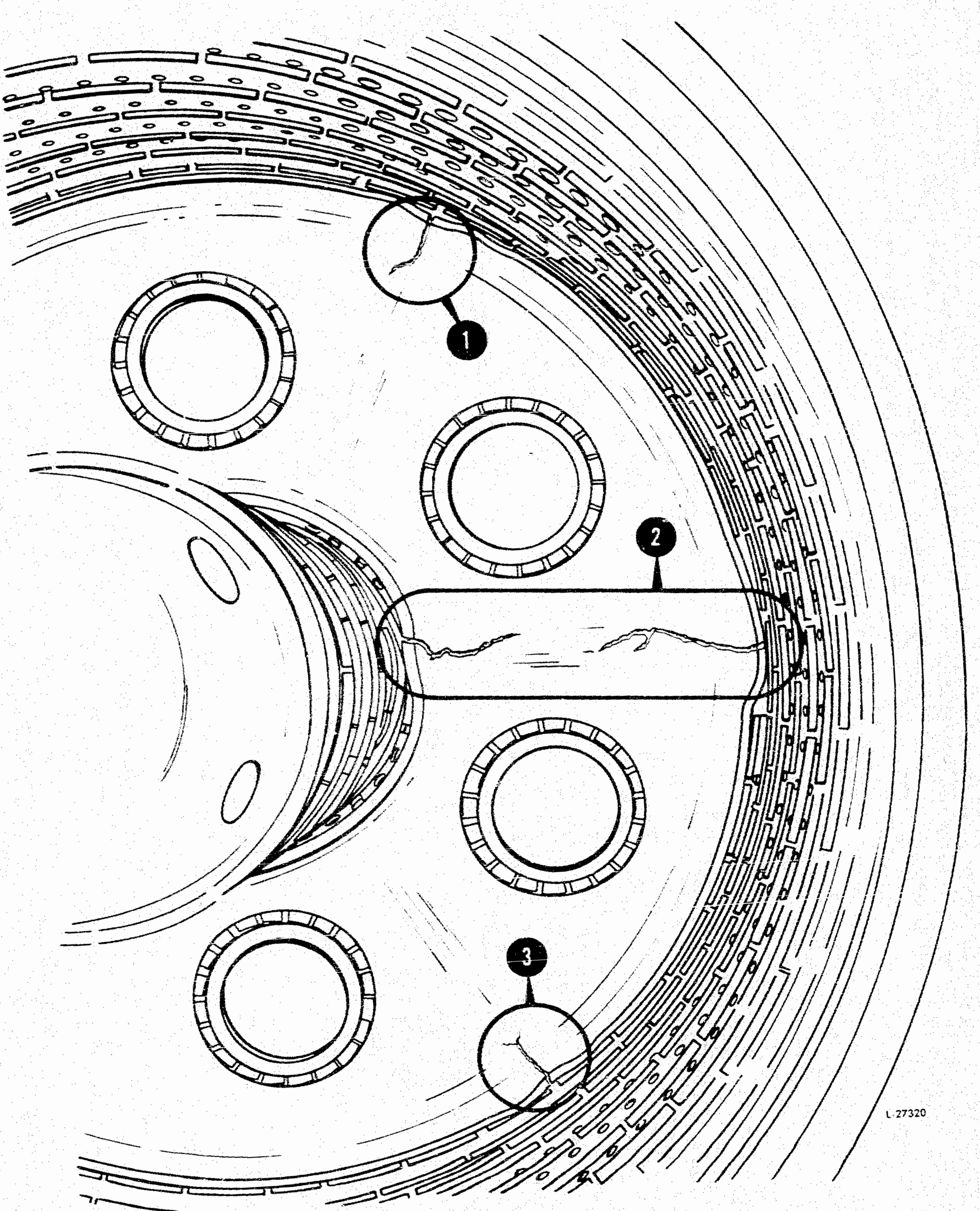
(3) An example of cracking typical of that found in the hot streak area is illustrated in Figure 620, Nos. 1 and 2. Repair by patching.

(4) Cracks in the outer liner as shown in reference number 2, Figure 619, are not acceptable. Repair this condition by patching the section.



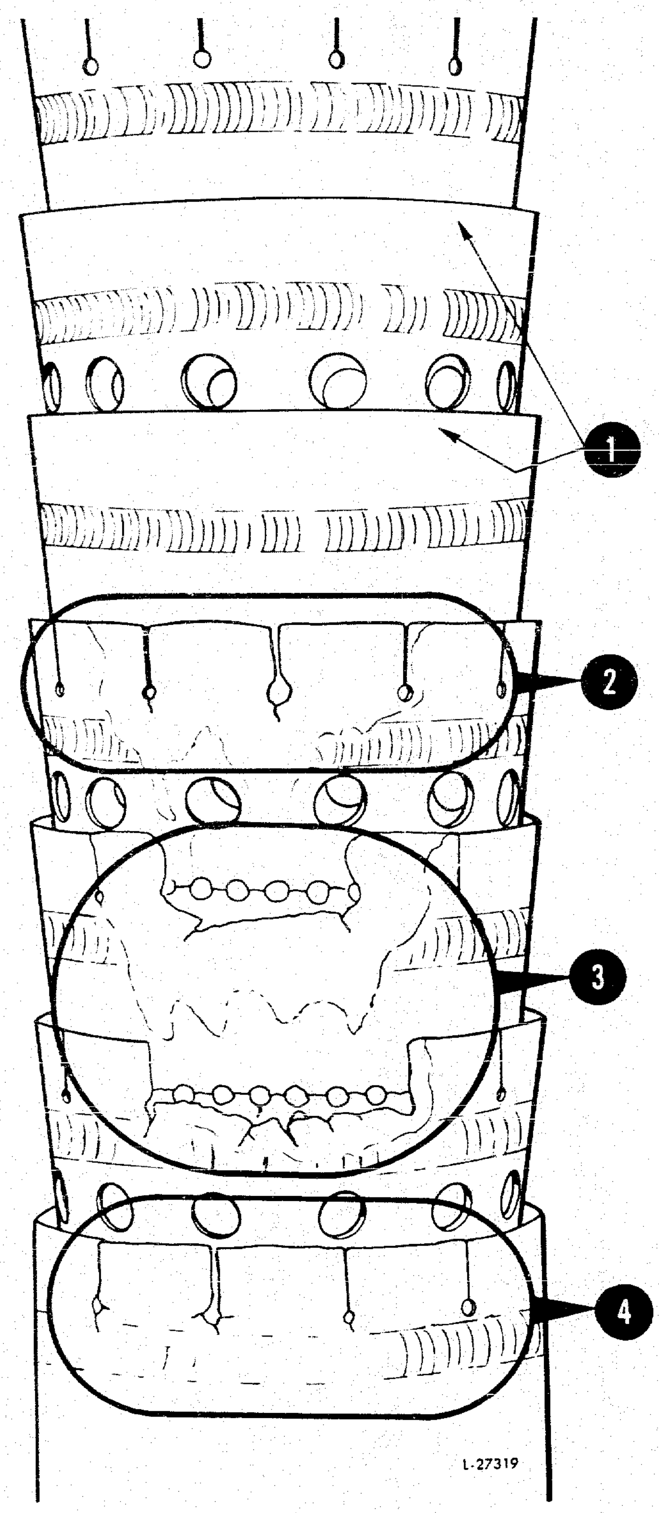
Combustion Chamber Wear

Figure 616



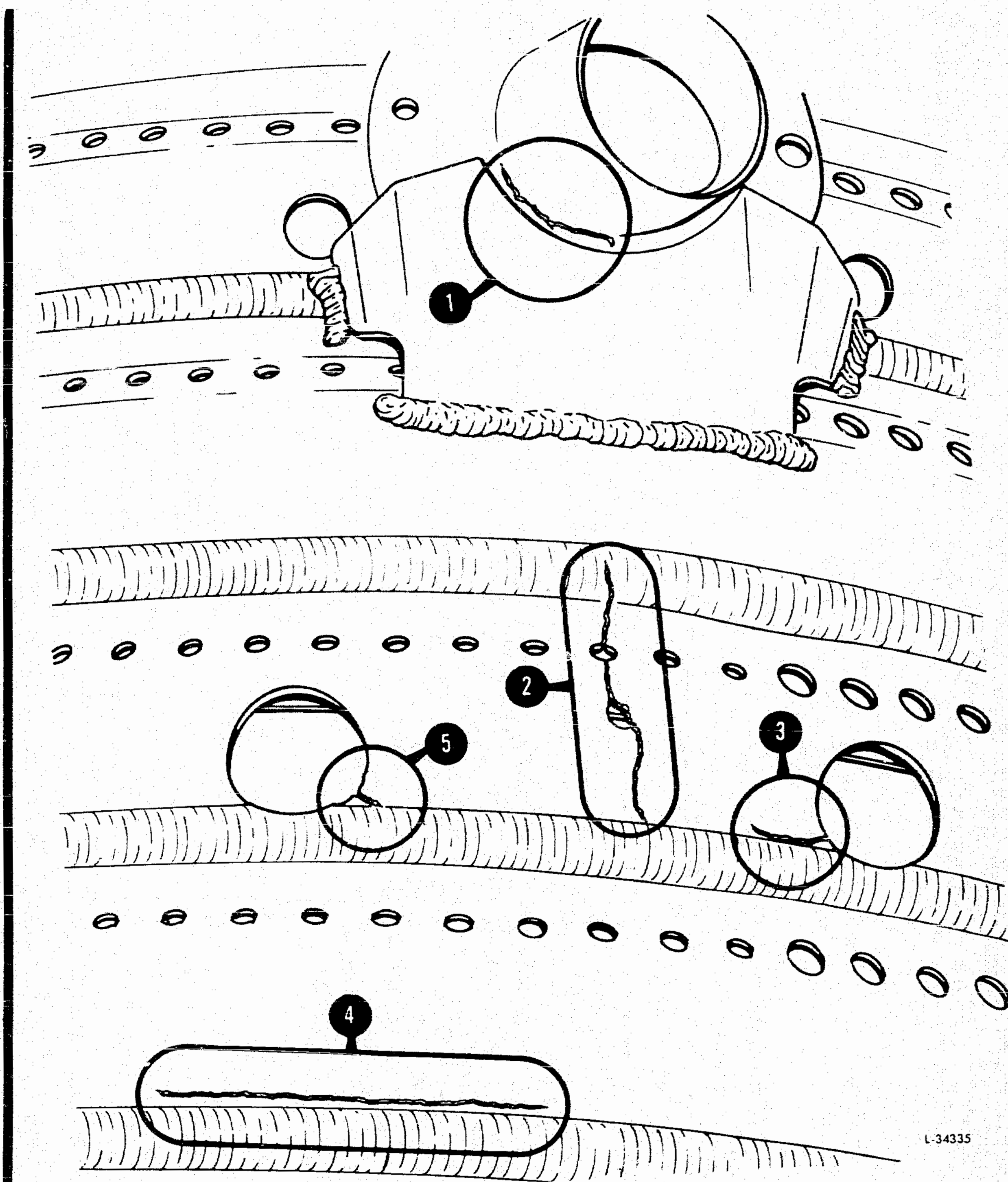
Combustion Chamber Wear

Figure 617



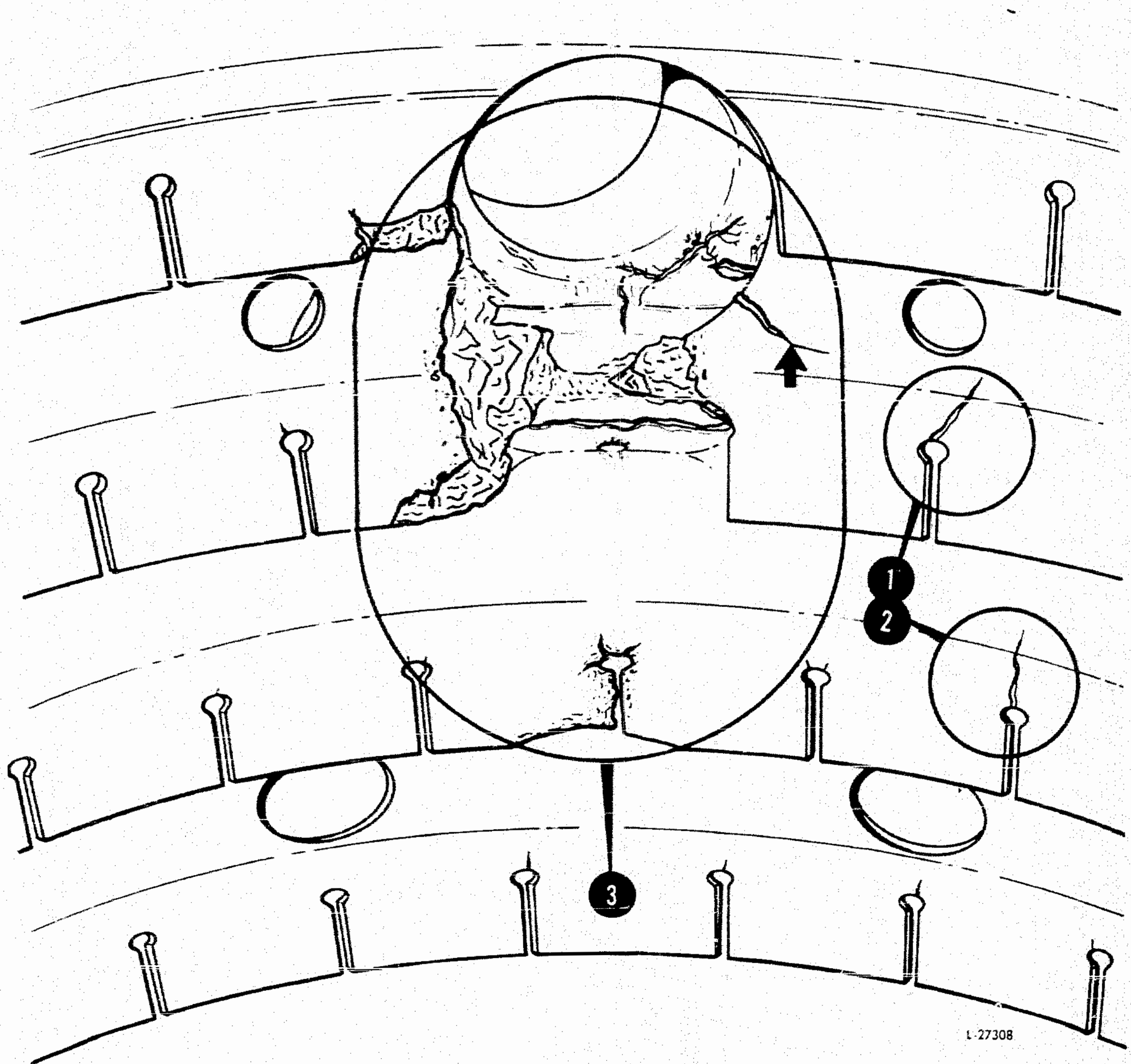
Combustion Chamber Liner Wear

Figure 618



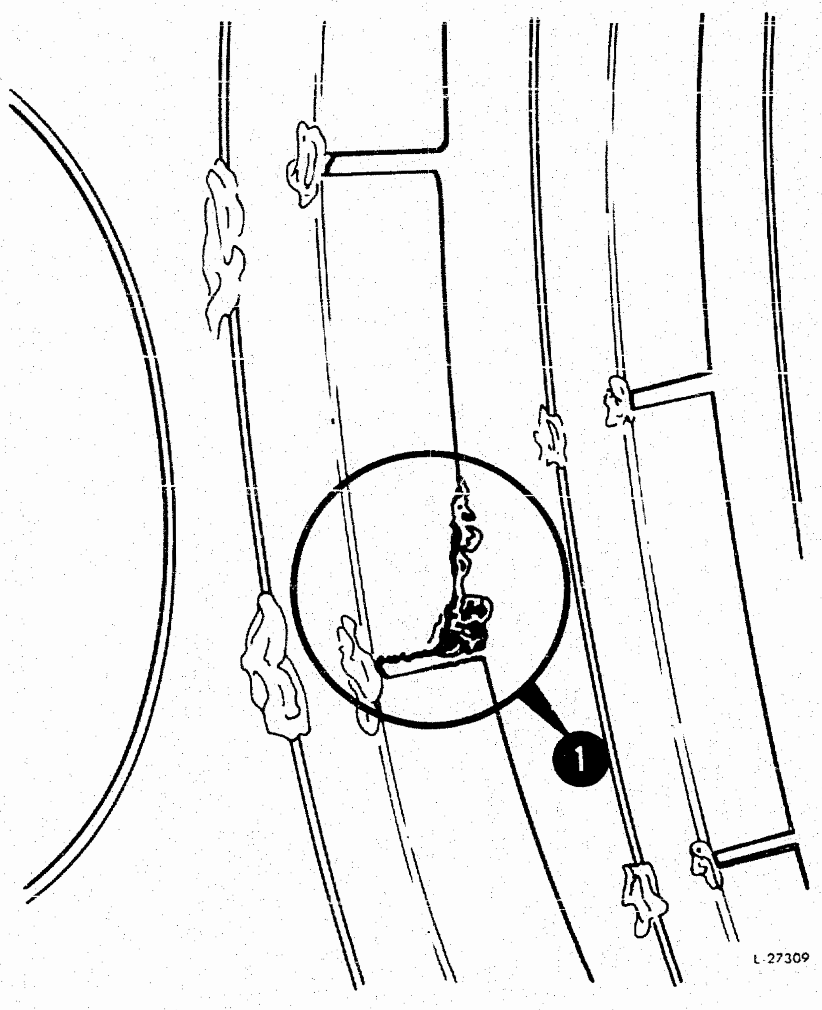
Combustion Chamber Cracks

Figure 619



Combustion Chamber Flame Tube and Liner Burning

Figure 620



Combustion Chamber Burning
Figure 621

(5) Cracks extending from the large holes of the liners as shown in reference numbers 3 and 5, Figure 619, are not acceptable. Repair these cracks by welding.

(6) Circumferential cracks immediately above or below the seam weld in the outer liners as shown in reference number 4, Figure 619, must be weld repaired. Such crack openings in excess of 0.030 inch are not repairable. There is no restriction on the length of this type crack repair.

(7) Cracks extending over 1/4 inch in length in the fuel nozzle swirl cups as shown in reference numbers 3 (Figure 616) or 2 and 3 (Figure 617), are acceptable provided they are weld repaired. See step (10).

(8) Slight burning of the swirl guide deflectors, reference numbers 2 and 4, Figure 616 is acceptable provided they are blended to the following limits:

(a) No more than cumulative length of 1.30 inch of the ID of the deflector or a cumulative total of the length of six vanes (including six vane spaces) may be blended to one-half the lip height.

(b) The blend must produce sound metal of generally uniform thickness. Do not remove more material than is necessary to achieve this.

(c) Buckling of the lip of the deflector beyond the blended areas is acceptable provided the buckled area is not burned and the general contour of the ID circumference is uniform.

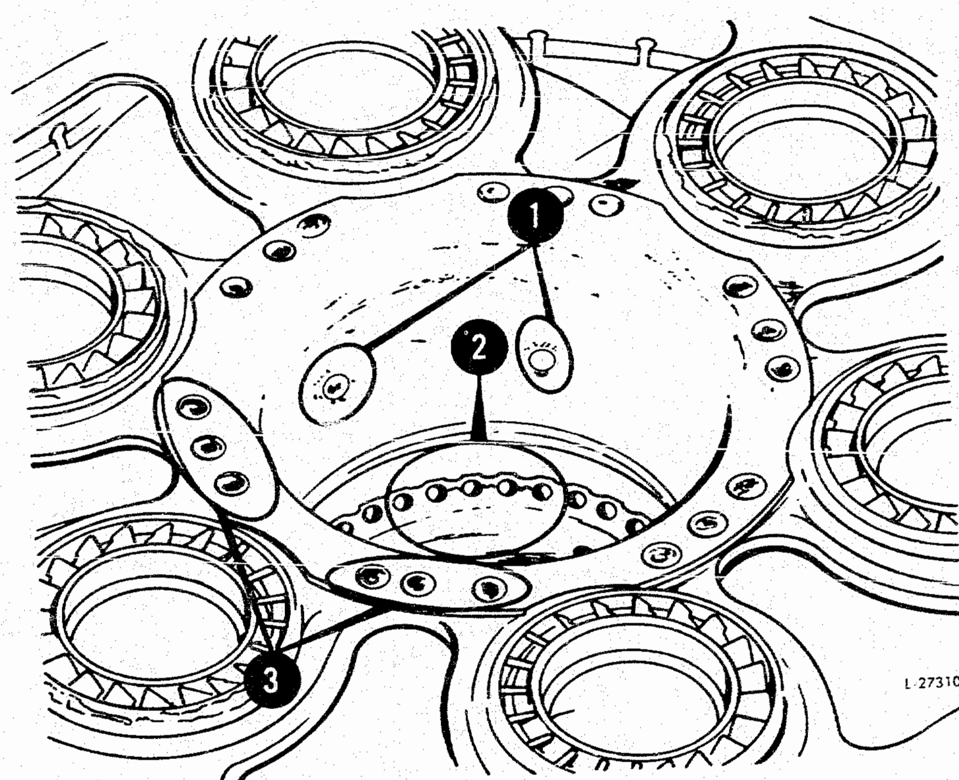
(d) Thinned and slightly buckled areas of the deflector's lip are acceptable without rework when burning has not occurred.

(9) Location of cracks in inner liner assembly which do not automatically reject assembly are as follows. All cracks must be weld repaired.

(a) In ID of front end of inner liner, around and emanating from six spot welds used, in early chambers only, to secure inner liner assembly to swirl cup inner brace. On Figure 622, Index No. 1, these spots have been sketched in.

(b) In flange of front end inner liner, around or emanating from spot welds or hand fusion welds used to secure inner liner assembly to cover. See Figure 622, Index No. 3, for location.

(c) In No. 1 inner liner only, circumferentially between small cooling air holes, between not more than four consecutive holes in any 120 degree sector (maximum of nine cracks per liner) provided groups are separated by a sector of sound material of at least 90 degrees. Examples are shown in Figure 622, Index No. 2.



Combustion Chamber Inner Liner Cracking
Figure 622

(10) Figure 623 show ventilated (louver cooled) swirl cup configuration. All inspection criteria for earlier, non-louver cooled swirl cup apply to new louver cooled configuration. In addition, following criteria are added applicable only to louver cooled configuration:

(a) Cracks in baffle must be repair welded. A copper shim or chill must be used in space between baffle and swirl cup to prevent burn through from restricting air flow.

(b) Cracks in baffle to swirl cup attaching weld must be routed and repair welded.

(c) Clearance between baffle and swirl cup must be within limits shown in Figure 624. If clearance is found below minimum, it is probably caused by distortion of swirl cup, not the baffle. Before bending baffle to restore clearance, inspect swirl cup for buckling and/or rolling inward of ID and correct these conditions if present. After bending baffle or swirl cup, inspect baffle attaching welds for cracks.

D. Unacceptable Conditions

(1) Cracks located in the fuel nozzle swirl cups as shown in reference number 2, Figure 617, are not acceptable. Repair of this type condition requires head replacement.

(2) Burning and cracking of inner liners as shown in Reference Number 3, Figure 618, are not acceptable. Replace the complete set of liners to repair this condition.

(3) Wall thickness of the No. 11 Outer Liner at any location must be 0.030 inch minimum. Below this minimum thickness combustion chamber liner must be replaced.

(4) Combustion chambers having locating lug hardface worn 0.010 inch or more are unacceptable for further service until repaired.

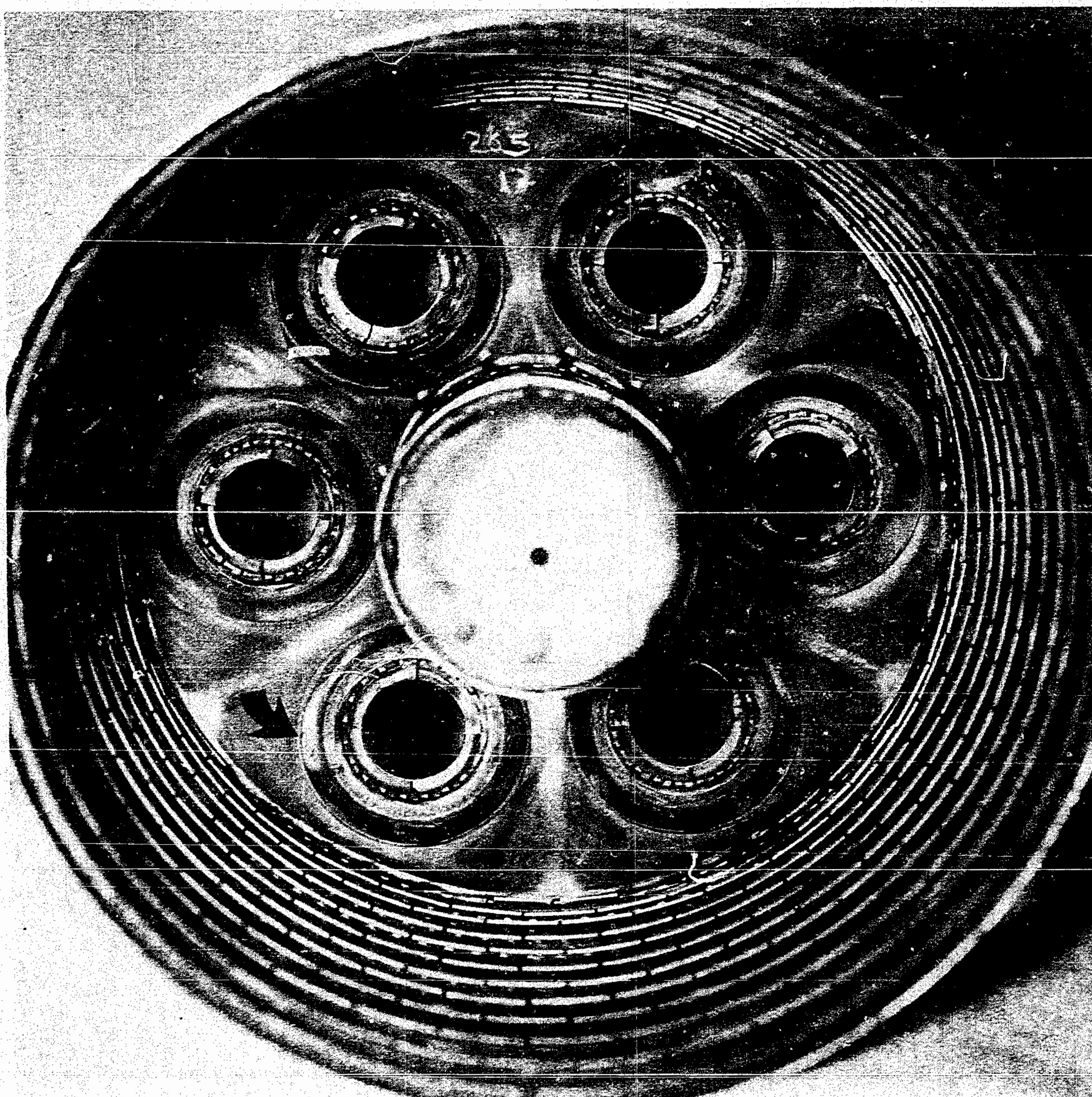
(5) Wear in swirl guide ID (bore) which increases ID to 1.263 inch diameter or over at any point is unacceptable (this wear is usually localized). Check ID with PWA-30018 Go-No-Go Gage.

E. Combustion Chamber Differences

See Figure 625.

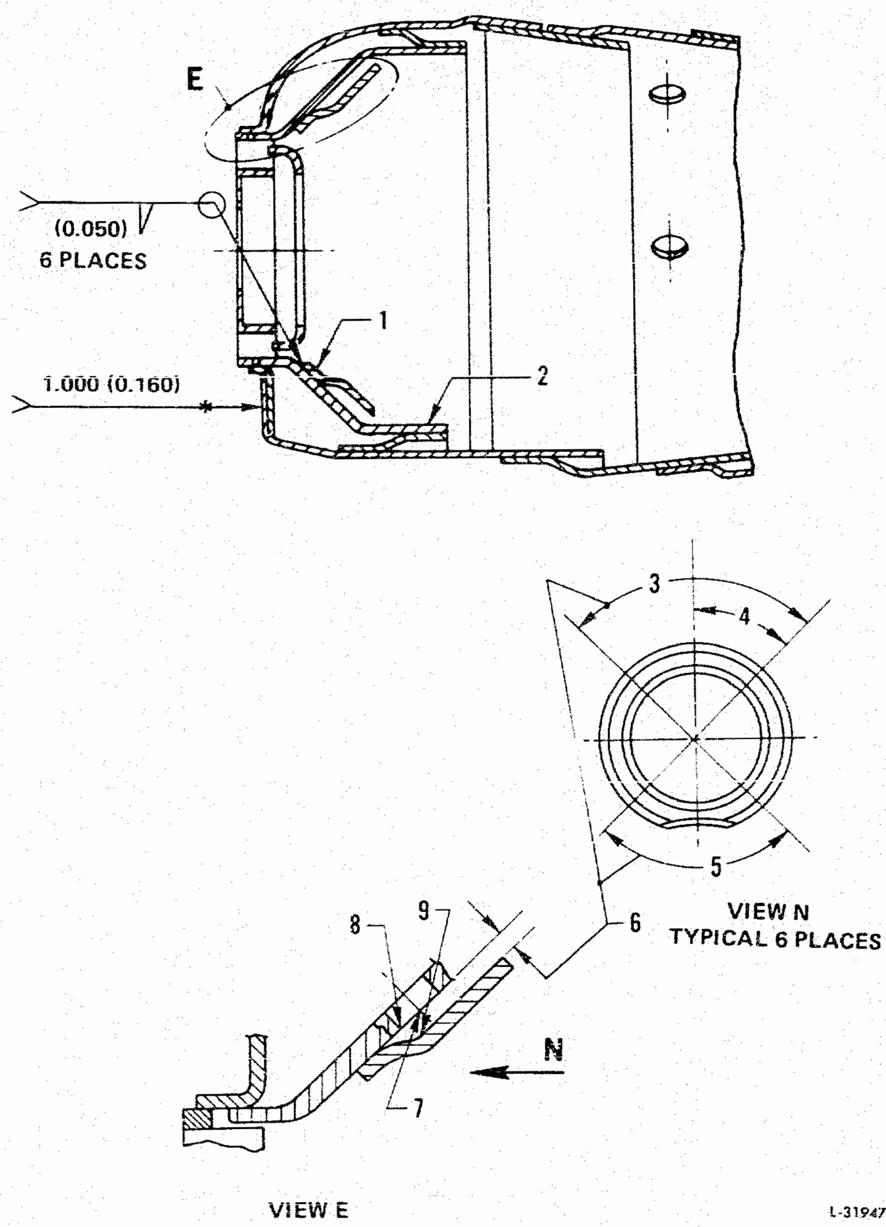
(1) There are three basic types of combustion chambers in service:

(a) Type I - Chambers in which all sheet metal parts are of Inconel material. All but very earliest of this group have torroidal type swirl guides.



Combustion Chamber (Louver Cooled Swirl Cup)

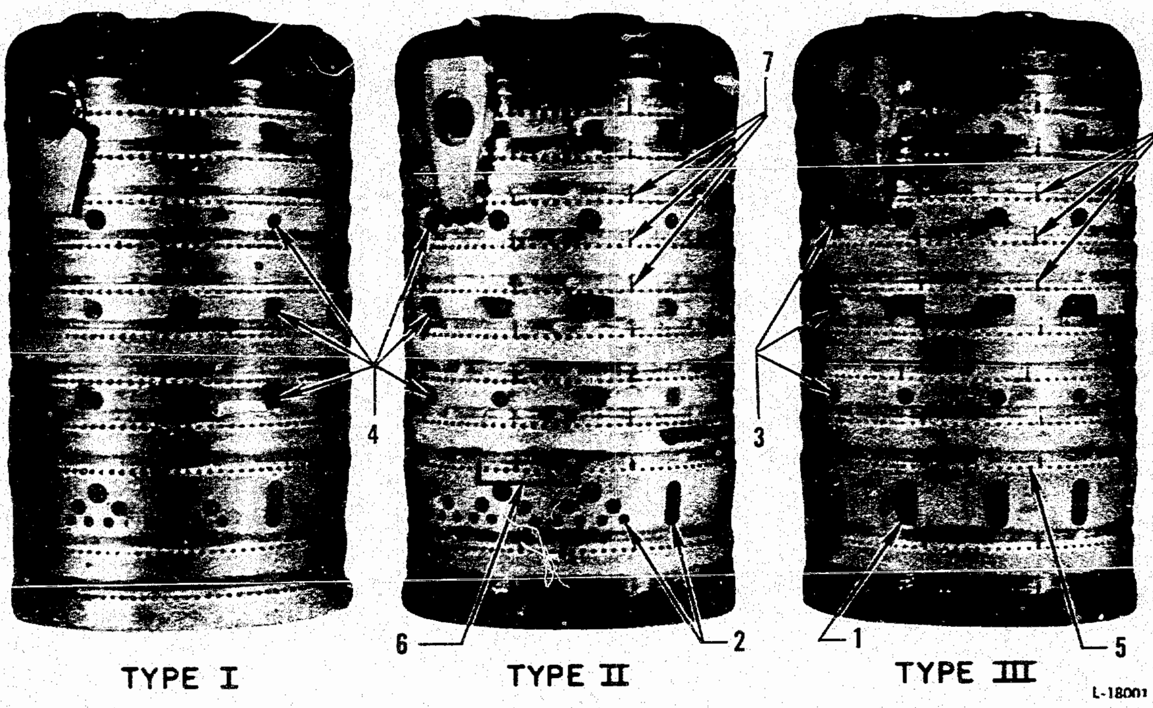
Figure 623



1. P/N 693309 Baffle
2. Fuel Nozzle Swirl Cup
3. 90°
4. 45°
5. 90°
6. 0.045 To 0.080 Inch Within Of Nos. 3 And 5. 0.045 To 0.095 For Remainder.
7. No Weld Expulsion In Holes.
8. Reference Surface
9. This Surface Must Not Overlap Edges Of Surrounding Holes. See No. 8.

Ventilated (Louver Cooled) Swirl
Cup Baffle Clearance

Figure 624



Type II and Type I

2. Combination of combustion air slots and holes. Note that early Type I (Not Illustrated) has slots only but slots are narrow.

4. Combustion holes in any one liner are of different diameters around chamber.

6. In any one liner, Nos. 1 thru 9, two groups of cooling air holes are slightly larger in diameter.

7. Seam weld interruptions only in later Type II and not in Type I.

Type III

1. Slots only. Note that slots are wider than those in Type II and Type I.

3. Holes same diameter in any one liner.

5. Holes same diameter in any one liner.

7. Seam weld interruptions in all Type III.

Combustion Chamber Differences

Figure 625

(b) Type II - Change from Inconel to Hastelloy material for increased durability was made gradually, starting with 453043 - 453046 series which incorporated at manufacture a full outer liner assembly of Hastelloy material. Latest of Type II chambers, P/N 490488 - 490491, Change letter K and subsequent, are all Hastelloy.

(c) Type III - Though physically interchangeable with Type I and Type II chambers, these chambers are definitely not functionally interchangeable due to entirely different pattern and size of combustion and cooling air holes in both inner and outer liner assemblies. Type III chambers are used in all JT3D-3B engines and only in those JT3D-1, JT3D-3, JT3D-1-MC6, and JT3D-1-MC7 engines which are in compliance with Service Bulletin Nos. 609 and 765.

(2) Following major features are used to distinguish between Type III chambers and those in combined Type II/Type I category:

(a) Combustion holes in No. 9 outer liner.

Type III chambers have slots only, completely around chamber. Type II/Type I chambers have a combination of slots and holes. Note that slots are wider in Type III chambers than in Type II/Type I. Very early Type I chambers had slots only, however, slots in early Type I chambers were of narrow variety and early Type I chambers had no seam weld interruptions.

(b) Combustion holes in Nos. 3, 5 and 7 outer liners.

In Type III chambers holes in any one liner are same diameter completely around chamber. In Type II/Type I chambers holes in any one liner are of different diameters.

(c) Cooling air holes in Nos. 1 through 9 outer liners.

In Type III chambers holes in any one liner are of same diameter. In Type II/Type I chambers there are a few cooling air holes at two places in each liner which are slightly larger than the others.

(3) Inner liners.

(a) Index No. 1 of Figure 618, illustrates the later slotless trailing edge inner liner, a design which will alleviate the conditions illustrated by Index Nos. 2, 3, and 4. Inner liner assemblies may be found with any number of slotless type individual liners interspersed among earlier slotted type. Inspection limits are the same for both slotted and slotless type liners and liner assemblies.

ENGINE - INSPECTION/CHECK

5. Combustion Chamber Outer Case

A. Combustion Chamber Outer Case-to-Diffuser Case Flange Air Leakage Check.

CAUTION: MARKING IS NOT PERMITTED ON COMBUSTION CHAMBER OUTER CASE EXCEPT AT OD OF FRONT FLANGE.

(1) Minor air leakage during engine operation at flange between diffuser case and combustion chamber outer case is acceptable. Heavy, concentrated leakage probably indicates severe warpage or damage to flanges and should be investigated by disassembly sufficient to determine condition of flange. Air leakage can be determined by passing a cloth along flange.

(a) Inspect scallops in forward OD flange contacted by combustion chamber positioning lugs. Cases with scallops having hardface inlay worn 0.010 inch or more are unacceptable for further service until repaired.

5A. Combustion Chamber Outer Rear Case

A. Cases being operated with one or two front flange bolt holes cracked through to flange OD must be inspected after each 500 hours of operation to assure that cracking does not initiate from cracked bolt holes toward center of case. Inspection to be visual with bolt removed at crack locations. If cracking is detected toward center of case, case cannot be continued in service. Repair for this cracking is not available and case is considered non-serviceable.

6. Combustion Chamber Outlet Duct

A. Anti-Rotation lug (P/N 570721)

(1) Inspect anti-rotation lug on outlet duct configuration incorporating louvered outer wall for bending and indications that outer wall has shifted in relation to diaphram of duct. Bent lug may be repaired in accordance with Section 72-0, Approved Repair.

7. Turbine Nozzle Outer Case

CAUTION: BECAUSE OF LIMITED SUCCESS AND RELIABILITY EXPERIENCED WITH THIS INSPECTION METHOD, IT IS URGED CAUTION BE USED IN ACTUAL OR CONTEMPLATED USE FOR FOLLOWING REASONS:

(1) INABILITY TO ACCURATELY CALIBRATE INSTRUMENTS DUE TO NON-AVAILABILITY OF CALIBRATION TOOL.

(2) PROBABLE "GRASSY" SIGNAL PRESENTATION DUE TO METALLURGIACAL CHANGES IN CASE MATERIAL RESULTING FROM SERVICE USAGE OR OXIDE/CONTAMINATION BUILDUP ON CASE EXTERNAL SURFACES.

(3) HIGH LEVEL OF OPERATOR SKILL REQUIRED TO CONDUCT INSPECTION.

A. Positioning Lugs (Third And Fourth Stages)

(1) Air seal and vane shroud positioning lugs may be inspected for cracks or missing pieces, without engine disassembly, by ultrasonic method if desired.

(2) Ultrasonic equipment, or equivalent, required:

NOTE: The names of companies provided below as a possible source for the required equipment is furnished for information purposes only. Pratt & Whitney Aircraft does not endorse equipment procured from these companies. Further, Pratt & Whitney Aircraft does not accept responsibility to any degree for the selection of such companies as a source of supply.

(a) Ultrasonic test unit, Branson 301.

(b) Search unit, Automation Industries type SMZ 5.0 MHz, 0.250 x 0.250 45°S or type SFZ 5.0 MHz 0.250 with special plexiglass guide.

(c) Cable with UHF to transducer michrodot connectors.

(3) Other equipment required:

(a) PWA 30973 Template, third stage.

(b) PWA 30974 Template, fourth stage.

(c) Special slotted template, third stage.

(d) Special slotted template, fourth stage.

(e) Test sample containing both good and cracked lug.

(4) Ultrasonic test equipment calibration

NOTE: Refer to applicable operating instructions for specific ultrasonic equipment being used.

(a) If type SFZ (straight longitudinal) search unit (transducer) is to be used, couple with special plexiglass guide to establish proper angle of tranducer, using oil to couple unit to guide.

(b) Couple transducer to test piece aligning with undamaged lug of stage to be inspected.

NOTE: Location of transducer to lug is critical and its axial distance from reference flange should be noted when established to adjust PWA 30973 and 30974 Templates. See Figure 626.

(c) Calibrate instrument so that pip return representing rear surface of lug lip appears slightly to left of center on screen while recessed lug surface appears on far left of screen.

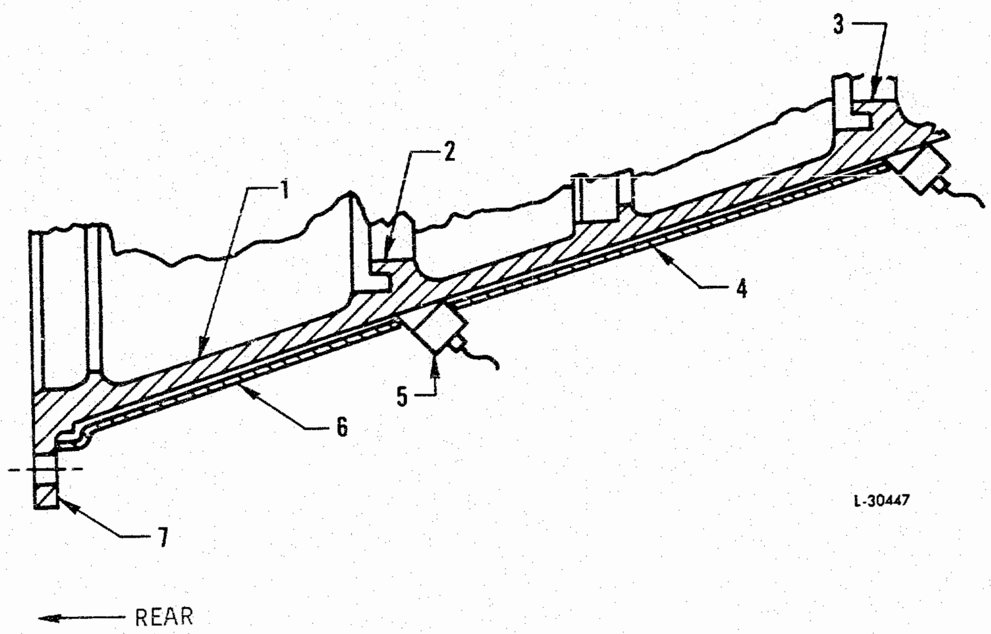
NOTE: Calibration must be made with a known cracked turbine nozzle case.

(d) Move transducer circumferentially over case toward adjacent lug, stopping between lugs. Observe new pip appear on screen right of center.

NOTE: With transducer properly positioned over lug, pip patterns may be moved to any position of screen by adjusting material calibrate knob. Assure they appear as described in substeps (a) through (d). See Figure 627.

(e) Continue moving transducer to cracked lug and observe pip for lug lip rear face disappear while traversing crack.

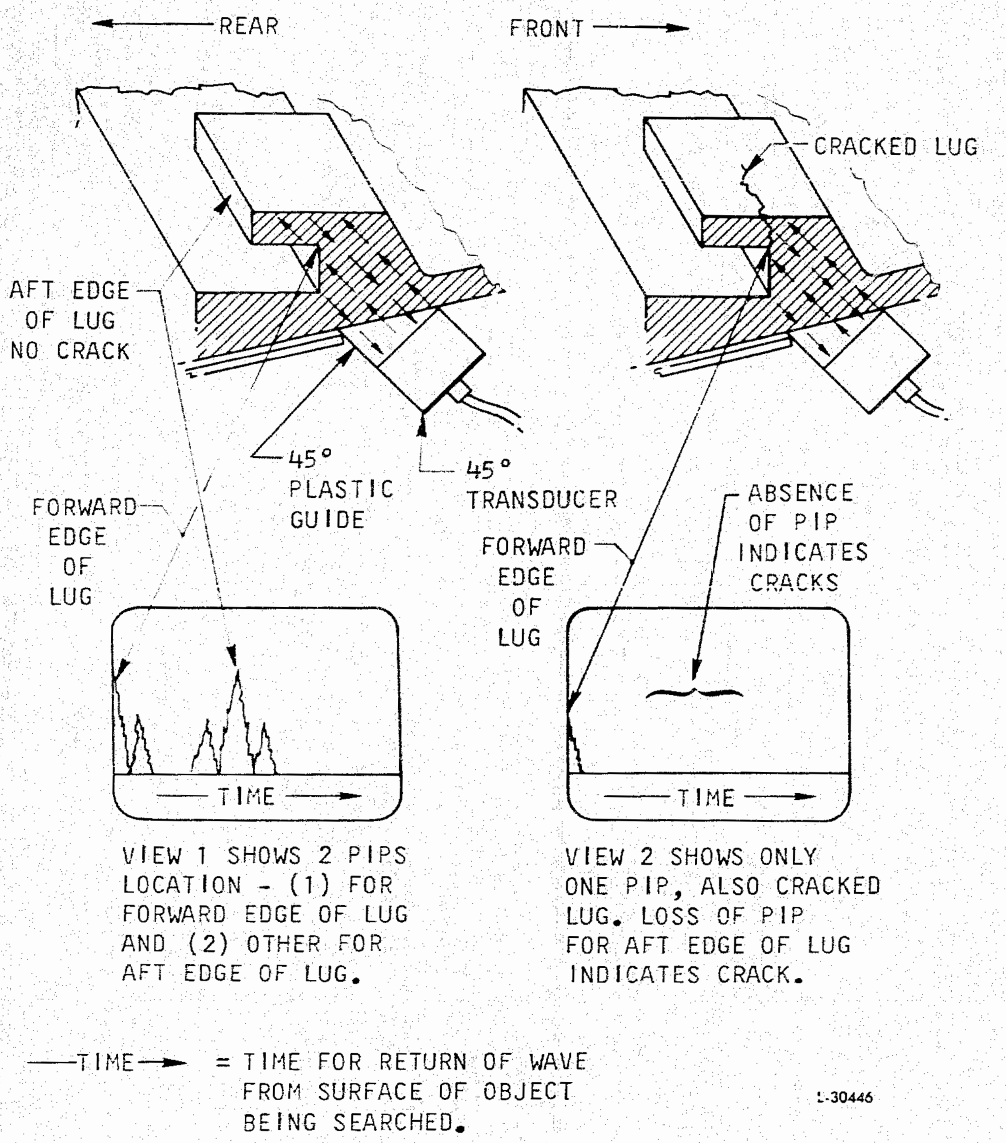
NOTE: Loss of pip from screen where lug lip rear face should be indicates sound energy is not reaching that surface, being interupted by either a cracked or broken lug lip. See Figure 627.



1. Turbine Nozzle Case
2. Fourth Stage Lug.
3. Third Stage Lug.
4. Template For Third Stage Lug Here
5. Transducer
6. Template For Fourth Stage Lug Here
7. Forward Surface of Turbine Nozzle Case.

Turbine Nozzle Case - Ultrasonic Test Template Locations
(3rd and 4th Stages)
Figure 626

ENGINE - INSPECTION/CHECK



Ultrasonic Inspection of 3rd and 4th Stage Turbine Nozzle Case Lugs
Figure 627

(f) Move transducer again over good lug, translating back and forth, noting pip patterns previously described to establish extremities of lug. Measure this distance on nozzle case to establish dimension of a slot to be cut in locally fabricated template (equipment item 3c and 3d). Template slot will represent lug width.

(5) Lug inspection procedure.

(a) Remove scale and other foreign matter from exterior of turbine nozzle case in area to be inspected.

NOTE: It is important that case surface be sufficiently clean to allow positive coupling of transducer with case metal.

(b) Affix appropriate PWA template (third or fourth stage) on nozzle case which will serve as axial locating guide for transducer.

(c) Couple transducer (with plexiglass guide if applicable) to case, using sutiable couplant.

(d) Move transducer circumferentially over case area to be inspected noting pip patterns.

(e) Identify lug lip rear face, recessed lug face, vane positioning pin hole area, and slot between lugs.

NOTE: Slight adjustments of equipment may be necessary to properly position pips (see calibration) due to tolerence differences. Axial positioning templates may also require adjustment.

(f) Using slotted template (equipment item 3c or 3d) scan each lug with transducer over its entire width.

(g) Except for vane pin area, about 0.250 inch, continuous and consistant pip pattern should appear for each lug traversed. If pip for lug lip rear face does not appear or disappears while traversing a lug (pin area excepted), a cracked or broken lug is indicated.

NOTE: Some nozzle cases will show indication of two vane pin recesses per lug, third stage only. This is due to pin relocat-ion and if consistant in their relative lug, location shall be considered satisfactory.

(h) Note findings and locations of suspect lugs, if any.

(i) Upon completion of lug inspection, clean couplant from case.

B. Third Stage Turbine Nozzle Vane Retention Lugs - On Wing Radiographic Inspection

See Figures 627A, 627B, and 627C.

(1) Equipment Required

(a) Radiation Source - Iridium-192 such as Technical Operation, Inc., Burlington, Mass. Model A-424-1 (capsule diameter 0.250 inches, 100 curie source dimension 0.100 inch diameter x 0.100 inches long).

(b) Source Positioning Tube

1 Obtain a radiation source positioning tube by any one of following methods:

a Locally fabricate a capped source positioning tube to accept an Iridium-192 source. Source positioning tube length should be approximately 116 inches. Diameter of section of source positioning tube (26 inches) that is passed into turbine shaft bearing oil pressure tube and heatshield assembly (bazooka) stiffener holes must be less than 0.490 inches. In order to clear internal structure, diameter of remaining length (90 inches) must be two inches or less.

b Procure a capped source positioning tube such as Technical Operations Model 583 (80 inch) source switch assembly and modify by addition of about 36 inches of 2 inch or less diameter pipe to compressor end of positioning tube.

c Procure a capped source positioning tube such as Technical Operations Model 727 (with a total 3-section length of 120 inches) commercially used on JT3D engines.

2 Locally fabricate tooling necessary to support compressor end of source positioning tube.

(c) Gamma Ray Projector

1 Obtain following gamma-ray projector equipment or equivalent:

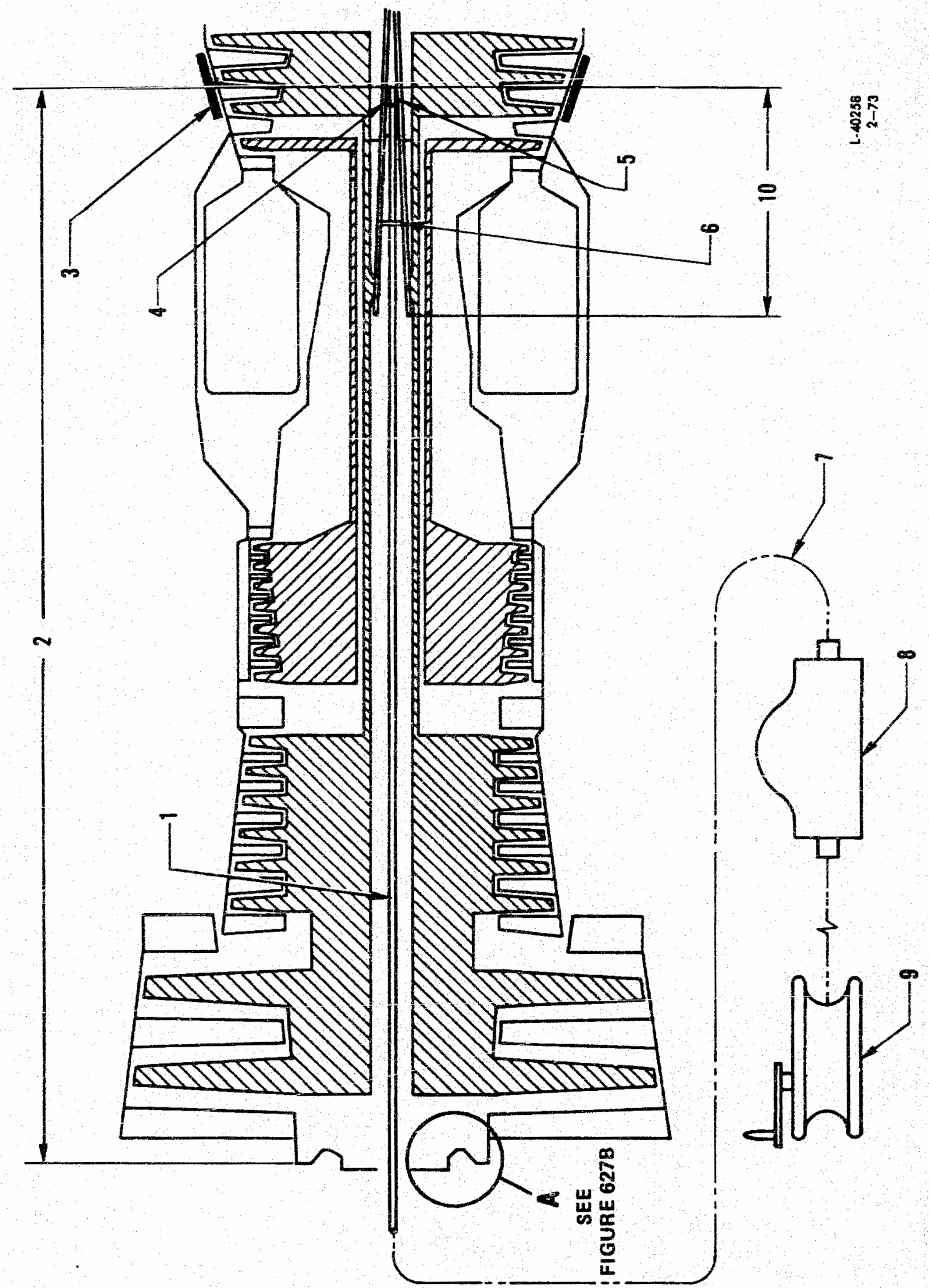
a Technical Operations Model 529 - Gamma Ray Projector Control

b Technical Operations Model 533 - Shielded Container

c Technical Operations Flexible Source Guide Tube

(d) Film - such as Kodak Type "M" or equivalent.

ENGINE - INSPECTION/CHECK



Isotope Inspection of Third Stage Turbine
Nozzle Case Vane Retention Lugs

1. Capped Source Positioning Tube (Source Travels Inside)
2. Source Position As Determined From Figure 627B.
3. Kodak Type M Film or Equivalent (7 x 17 Inches), 7 Sheets Per Stage
4. Iridium - 192 Source
5. Cap
6. 0.490 To 0.510 Inch Diameter Hole In Turbine Shaft Bearing Oil Pressure Tube And Heatshield Assembly (Bazooka).
7. Flexible Guide Tube
8. Shielded Container
9. Gamma Ray Projector Control
10. Approximately 24.320 ± 0.250 Inches

Key To Figure 627A

(2) Radiography Procedure

(a) Move aircraft to remote area that affords protection from radioactivity.

WARNING: ISOTOPE RADIOGRAPHY MUST BE PERFORMED BY QUALIFIED PERSONNEL, AND ALL APPROPRIATE SAFETY PRECAUTIONS MUST BE OBSERVED.

(b) Remove compressor inlet cone assembly, front accessory drive cover, and main front accessory drivegear in accordance with 72-00, Dismantling/Assembly.

(c) Insert source positioning tube into engine core for a distance as selected from Figure 627B or 24.300 ±0.250 inches aft of bazooka tube forward face. See Figures 627A and 627B.

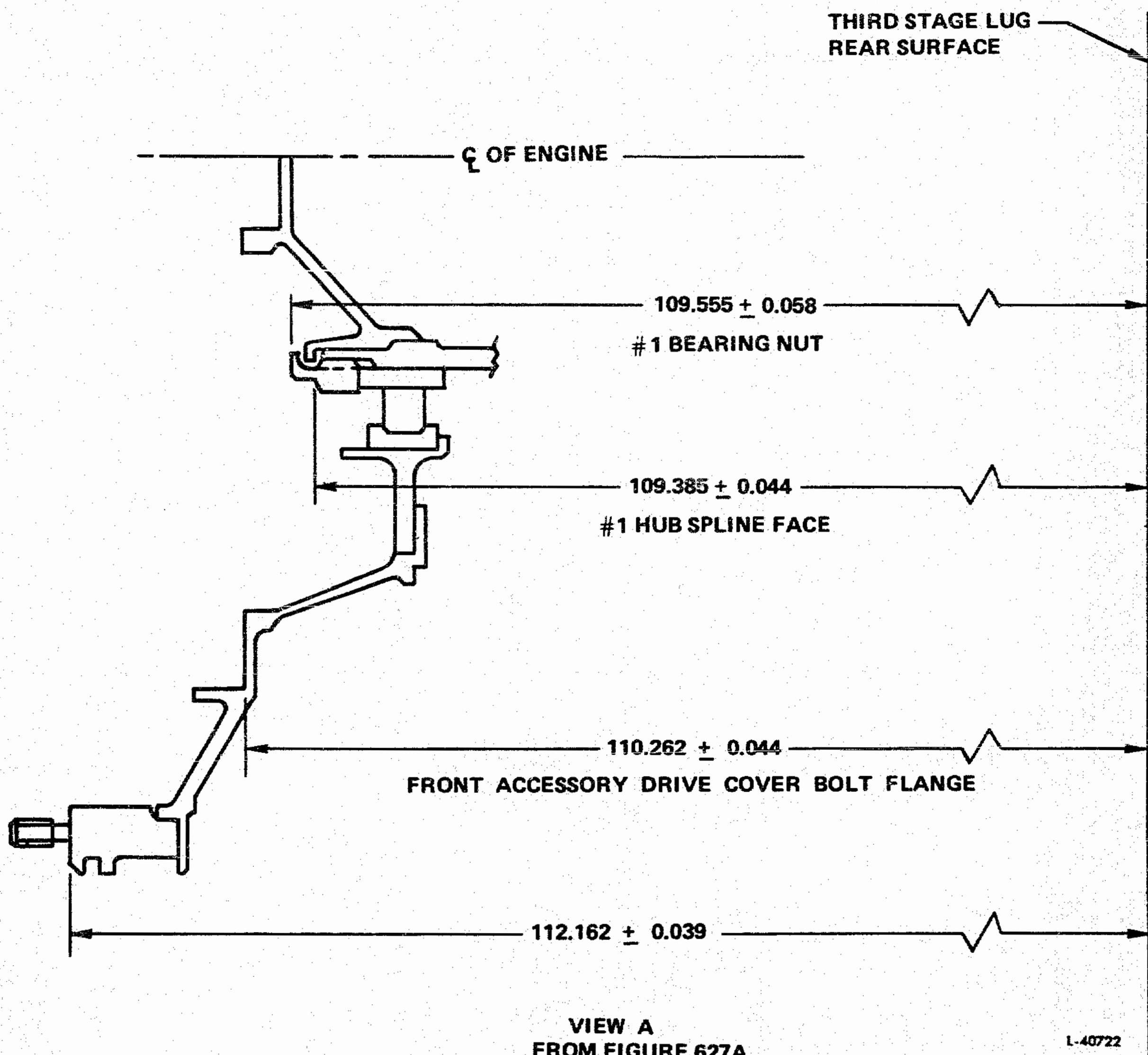
NOTE: Insertion dimensions are for reference only. It is suggested that trial X-rays be made to determine best position for radiograph definition. Mark tube for future reference.

ENGINE - INSPECTION/CHECK

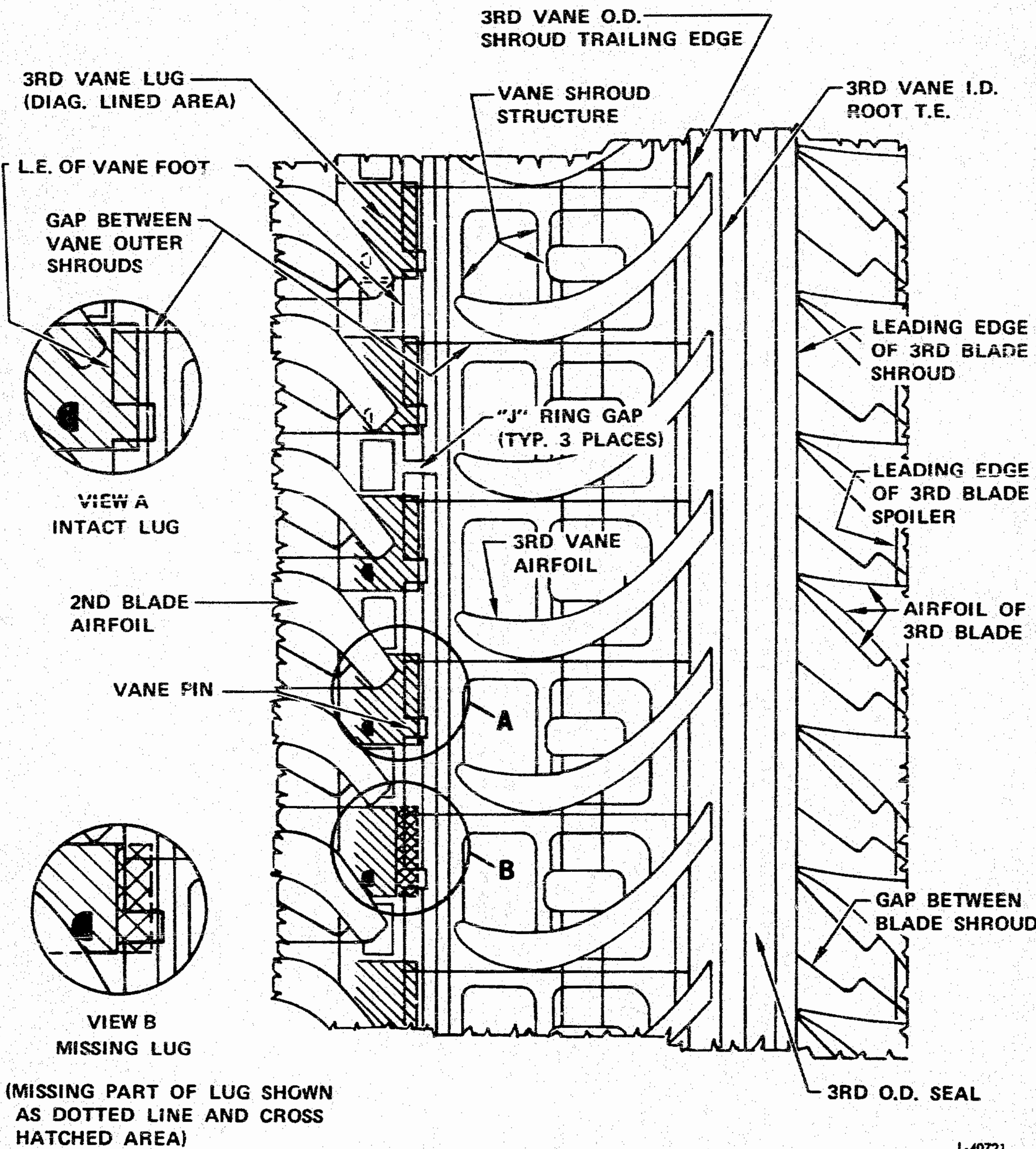
(d) Tape seven films, 7 x 17 inches, end to end around circumference of turbine nozzle case with rear edge of film in contact with forward face of "L" flange. Place 5 mil lead screens in front and back of film. Number films one through seven, clockwise from rear, starting at twelve o'clock position. Place numbers one inch aft of hinge of film holder. Mark engine number on No. 1 film.

(e) Using projector equipment, position Iridium-192 source fully into source positioning tube.

NOTE: If source positioning tube without source switch is used third light, labeled "ON", on gamma ray projector control will not operate.



Reference Distances to Third Stage Lugs for
Isotope Inspection (Compressor Inlet Cone Support Assembly)



Interpretation of Third Stage Turbine
Nozzle Case Vane Retention Lug Radiograph

Figure 627C

ENGINE - INSPECTION/CHECK

(f) Expose film as follows for type of film being used:

NOTE: Exposure times based on operator supplied information except as noted.

RADIOGRAPHIC EXPOSURE INFORMATION

FILM TYPE	RELATIVE SPEED	EXPOSURE CURIE-MINUTES
Kodak Type "M"	35	240
Kodak (Great Britain) Industrix "D"	520*	130
Dupont 75	12	114
Kodak Type "AA"	100	160**

*Approximate relative to AA per Kodak
**Estimated

TABLE I

(g) Develop film per manufacturer's recommendations.

(3) Radiograph Interpretation

(a) Evaluate radiograph film as follows:

1 Using Figure 627C as a guideline, identify on radiograph, following structure and part images.

a 3rd vane airfoil.

b 3rd vane foot leading edge line - directly rearward of 2nd stage blade trailing edge.

c 3rd vane pin.

d Line representing spacing between 3rd vane outer shrouds or vane shroud gap line - dark line perpendicular to vane foot leading edge line just below convex side of 3rd vane airfoil.

2 Turbine nozzle case vane retention lugs are spaced vertically between trailing edge of 2nd stage blades and leading edge of 3rd vanes, one for each vane. As illustrated in two circular "blow-ups" in Figure 627C, lug area is shaded with diagonal lines. Portion of lug which breaks is shown by cross-hatched lines.

3 If lug is intact, its upper and lower image lines will cross over and continue aft of vane foot leading edge image line for approximately one-half depth of vane foot pin image. Lug rear edge image line, connecting upper and lower lug image lines, will be parallel to vane foot leading edge image line, running vertically through vane foot pin image. These lines are shown as dotted lines in missing lug "blow-up."

4 If lug is missing, vane foot leading edge line image will be defined sharper than when lug is present. Amount of improved definition of vane foot leading edge line will be equivalent in definition to foot leading edge image line between lug area.

5 It is also noted in interpreting radiographs that a small, approximately 1/8 inch long, dark image will show up three times, in a full set of seven radiographs, in lug area. These images are caused by gaps between 3 segments of "J" ring, P/N 513539, positioned directly inboard of retention lugs.

(4) Resultant Action

(a) Remove nozzle cases that show evidence of one (1) or more broken third stage turbine nozzle vane retention lugs for visual confirmation and corrective action.

NOTE: This procedure may not lend itself to detection of cracked lugs.

8. Turbine Vanes - Inspection Procedures

A. Disruptions in the chromalized surfaces of the 1st stage vane are not cause for rejection. Vanes having nicks or dents should be replaced. Visually inspect vanes for signs of bowing. Replace vanes which are bowed in excess of 0.075 inch on the trailing edge with vanes of the same classification. A straight edge and feeler gage stock shall be used to measure bowing. Any or all vanes may be replaced with vanes of the same class without measuring the nozzle guide vane area.

B. First Stage Nozzle Vanes Cracks - Trailing Edge

(1) First stage turbine guide vanes exhibiting cracks in trailing edge may be continued in service provided:

(a) Cracks do not exceed 0.400 inch in length.

(b) Cracks are separated by a minimum of 1.000 inch.

(c) Cracks are not within 0.500 inch of fillet area of OD and ID buttresses.

NOTE: Cracks in trailing edge only, exceeding 0.400 inch but less than 0.500 inch may remain in service for 200 hours maximum.

C. First Stage Turbine Nozzle Vanes Bow Detection - On The Wing Radiography Inspection (JT3D-3B Engines).

WARNING: ISOTOPE RADIOGRAPHY MUST BE PERFORMED BY QUALIFIED PERSONNEL, AND ALL APPROPRIATE SAFETY PRECAUTIONS MUST BE OBSERVED.

NOTE: Inspect all engines which show performance deterioration as determined by flight log monitoring.

(1) Move aircraft to remote area that affords protection from radioactivity.

(2) Remove front accessory drive support and front accessory drive main gear per Section 72-0, Dismantling/Assembly.

(3) Locally fabricate a tube to accept Iridium-192, type 100C source to fit through 0.490 inch diameter hole in turbine shaft bearing oil pressure tube and heatshield assembly. See Figure 628. Insert a cap in inner end of tube to provide locating stop for source when it is in position. Mark tube 107.125 inches from capped end for reference on depth of insertion.

(4) Locally fabricate tooling necessary to support tube in position.

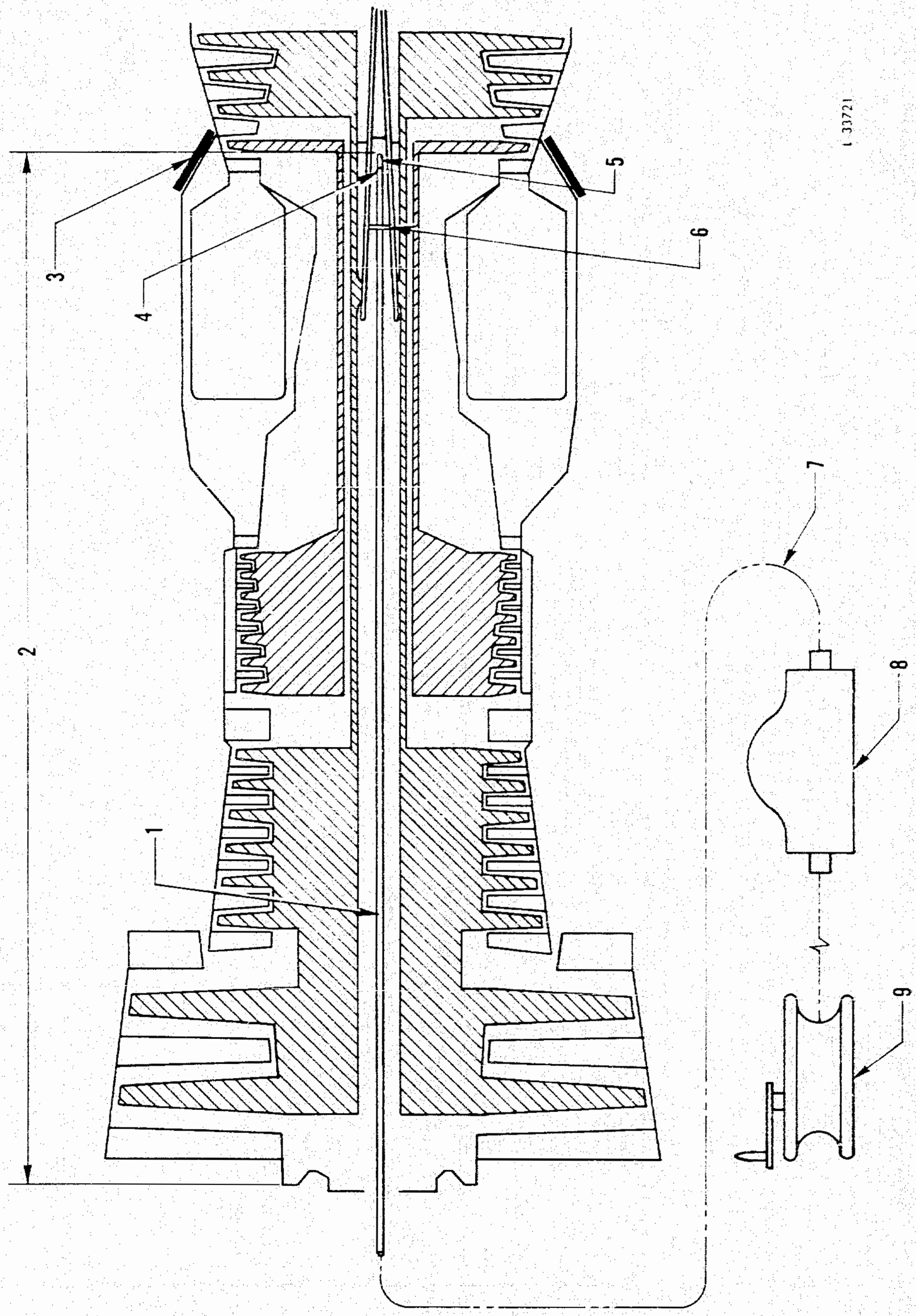
(5) Attach 0.010 inch lead screens on both front and back of film. Place film, Kodak type "M" 7x17 inches, around front of turbine nozzle case. Butt film against aft side of "K" flange and attach to flange by hinge on film holder. See Figure 628.

NOTE: Equivalent type film may be used when exposures are adjusted to give same results.

(a) Tape film to turbine nozzle case.

(b) Number films one through seven clockwise from rear starting at twelve o'clock position and placing numerals one inch aft of hinge of film holder. Mark engine number on No. 1 film.

(6) Crank source tube into core of engine until 107.125 inch mark on tube lines up with front face of compressor inlet cone support assembly.



Isotope Inspection Of First Stage
Turbine Nozzle Vanes (JT3D-3B)

1. Capped Tube (Source Travels Inside)
2. 107.125 Inches
3. Kodak Type M Film (7 x 17 Inches), 7 Sheets.
4. Iridium-192 Source
5. Cap
6. 0.490 - 0.510 Inch Diameter Hole In Turbine Shaft Bearing Oil Pressure Tube And Heatshield Assembly.
7. Flexible Guide Tube
8. Shielded Container
9. Gamma Ray Projector Control

Key to Figure 628

(7) Obtain following gamma-ray projector equipment or equivalent.

(a) Technical Operations Model 529-Gamma Ray Projector Control.

(b) Technical Operations Model 533-Shielded Container.

(c) Flexible Guide Tube

NOTE: Technical Operations Inc., Burlington, Mass. have indicated they would be willing to furnish equipment required.

NOTE: Third light on control box is not used since source switch for this light cannot be used. Source switch will not pass through 0.490 inch diameter hole in turbine shafts bearing oil pressure tube and heatshield assembly.

(8) Using projector equipment crack source out and expose film for 875 curie/minutes.

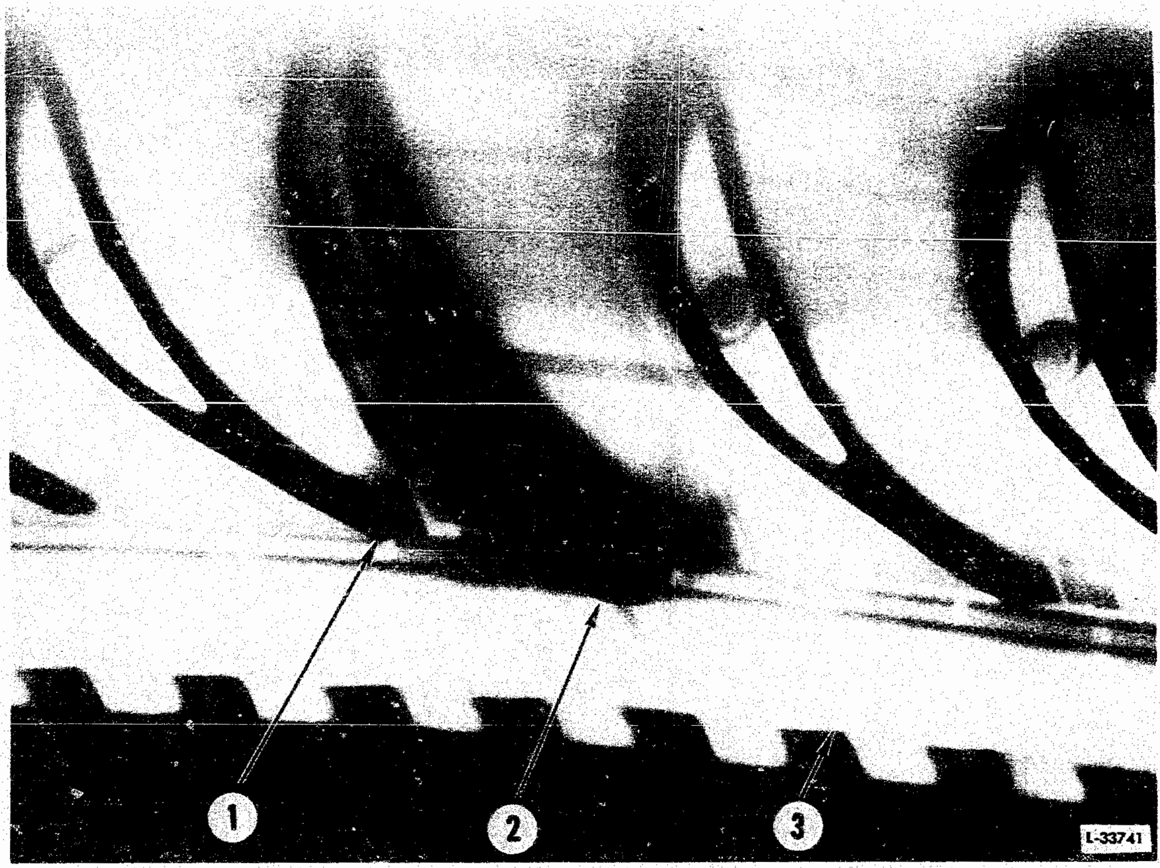
NOTE: Curie/minutes are determined from actual exposure in minutes multiplied by power source - type 100C power rated at time of exposure.

(9) Develop film per manufacturers recommendations.

(10) Analyze first stage turbine blade turbine nozzle vane condition and relationship.

(11) Replace all vanes that show evidence of abnormal bow. See Figure 629 No. 2.

NOTE: Limits of abnormal bow will be determined by each operator, which can only be arrived at by experience and repeated isotope inspections. Magnification factor will vary due to location of maximum bow along trailing edge of vanes.



1. Trailing Edge Turbine Nozzle Vane

2. Bowed Turbine Nozzle Vane

3. Leading Edge Turbine Blade

First Stage Turbine Vane Bow (JT3D-3B)
Figure 629

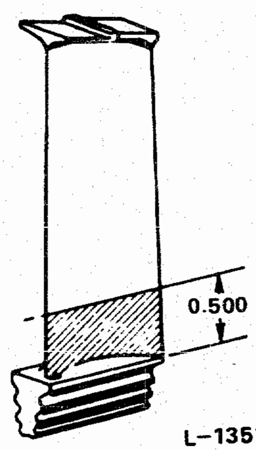
9. Turbine Blades - Inspection Procedure

A. Blades with nicks or dents in the airfoil within one-half inch of root platform (see Figure 630) can be blended if the damage is not detectable on the opposite side of the airfoil from which they were struck and the repair will not reduce the local airfoil thickness by more than 0.005 inch or chord length by more than 0.010 inch. Blades with nicks or de... s in the airfoil (but not in the above areas) may be blended if the detectable protrusion on the opposite side of the airfoil from which they were struck is not more than 0.010 inch above adjacent undamaged surface and the repair will not reduce the local airfoil thickness by more than 0.015 inch or the chord length by more than 0.025 inch. Any number of turbine blades may have axial play up to 0.015 inch at blade root and disk, providing the rivet heads are sound and undamaged.

B. Turbine Blade Inspection

(1) Inspect the first stage turbine blades for deformation of the leading edge as follows:

(a) With a strong spot light (150 watts minimum) inspect each turbine blade for waviness or deformation of the leading edge.



Turbine Blade Repair Limits

Figure 630

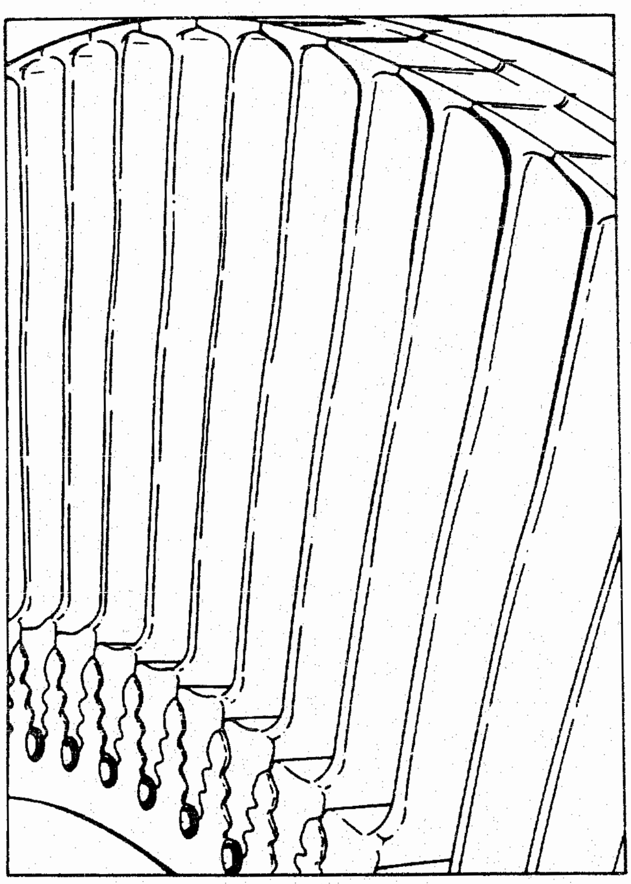
ENGINE - INSPECTION/CHECK

(b) Deformation due to overtemperature, may appear as a waviness and/or areas of varying airfoil thickness along the leading edge (see Figure 631). The leading edge must be straight and of uniform thickness.

NOTE: Do not confuse deformation of the leading edge with blending repairs to the blade. If confusion exists, check the blade for stretch.

(c) Remove a segment of the first stage vanes to facilitate inspection of the blades.

(d) When any deformation of the leading edge of first stage turbine blades is found, an overtemperature conditon has occurred. Therefore, reject all the blades.



L-48200
3-75

Turbine Blade Deformation

Figure 631

ENGINE - INSPECTION/CHECK

10. First Stage Turbine Blade Stretch (Blade PN 55910)

A. To check the first stage turbine blades for stretch, proceed as follows:

(1) Push back the combustion chamber outer cases and remove the combustion chambers. See 72-0, Approved Repair.

(2) Remove segment of 1st stage turbine vanes in manner outlined in 72-0, Approved Repair.

(3) Use Detail-1 of PWA 31052 Stretch Gage having length of 3.3580 inches which is equivalent to 0.013 inch stretch. 3.3580 is marked on gage. For this blade stretch limit is 0.013 inch.

NOTE: Stretch trend check may be made in addition to stretch limits check if desired. To accomplish check, use PWA 31052 Gage, Detail-2. Detail-2 has length of 3.3515 inches which is equivalent to 0.0065 inch stretch. 3.3515 is marked on gage. Detail-2 is used to check stretch trend only.

(4) Insert gage through nozzle opening placing convex surface of gage against machined step at root of blade; sweep other end of gage over blade shroud.

(5) Blade is excessively stretched if stretch limit gage interferes with blade shroud.

(6) Rotate high compressor drive turbine rotor to position blades to be measured.

NOTE: Due to removal of combustion chamber outer cases, difficulty may be experienced in turning rotor. This may be alleviated by supporting turbine nozzle case using PWA 17205 Supports (4) set 90 degrees apart.

B. Perform a stretch check on 1st stage blades when EGT exceeds established limit. If any blade exceeds maximum stretch limit, entire turbine should receive overhaul inspection.

ENGINE - INSPECTION/CHECK

11. Inspection of Engines Subjected to Overtemperature

    See 72-0, Adjustment/Test.

12. Inspection of Engines Subjected to Overspeeding

    See 72-0, Adjustment/Test.

ENGINE - INSPECTION/CHECK

13. Freedom of Rotation Check

A. Perform following freedom of rotation check to reduce possibility of subsequent damage by foreign objects.

CAUTION: ENGINE MUST BE TURNED IN NORMAL DIRECTION OF ROTATION ONLY (COUNTERCLOCKWISE WHEN FACING THE ENGINE INLET).

B. Prior to engine checkout, high compressor must be rotated by turning starter drive and low compressor rotated manually by first stage compressor blades.

C. If there is any unusual resistance or unusual sound, an investigation must be made to determine the cause.

14. Front Compressor Case and Vane Assembly

A. First Stage Compressor Vane Spacer

(1) Cracked spacers may be continued in use until crack extends completely across spacer.

(2) Remove spacers which are cracked across entire spacer as follows:

(a) A maximum of six spacers may be removed.

(b) Do not remove two adjacent spacers or more than two spacers in same 90° quadrant.

B. Anti-Icing Air Ports

(1) Cracks in area of anti-icing air ports up to two inches may be continued in service to nearest repair facility.

(2) Weld repair cracks as soon as possible.

15. Inspection Of Engines Shut Down In Flight

A. If there has been continuous positive indication of oil pressure (5 psi or higher) following shutdown, engine may be continued in service after satisfactory inspection of main oil filter following servicing of engine and ground run-up.

B. An engine windmilling for 30 minutes or less with less than 5 psi oil pressure after shutdown may be continued in service after satisfactory inspection of main oil filter, servicing, and ground run-up.

ENGINE - INSPECTION/CHECK

C. An engine windmilling for more than 30 minutes but less than 60 minutes with less than 5 psi oil pressure after shutdown may be continued in service after satisfactory inspection of main oil filter, servicing, and ground run-up. Repeat oil filter check after first flight, 15 hours, 50 hours, and 100 hours.

D. Engines windmilling for more than 60 minutes with less than 5 psi oil pressure after shutdown shall be sent to overhaul for bearing inspection. Particular attention must be given to No. 2, No. 4, and No. 5 bearings.

NOTE: Operating conditions prior to and after interruption and windmilling should be accurately recorded to determine classification of windmills.

CAUTION: ANY POWER ON OPERATION AT OR ABOVE IDLE WITH OIL PRESSURE OF 5 PSI OR LESS SHALL REQUIRE THAT ENGINE BE SENT TO OVERHAUL FOR BEARING INSPECTION.

E. If oil supply was shut off or interrupted for more than 10 seconds at speeds in excess of windmilling or before engine decelerated to windmilling speed following engine shutdown, record conditions of operation and send engine to overhaul for bearing inspection. Particular attention must be given to No. 2, No. 4, and No. 5 bearings.

NOTE: Interrupted shall be zero oil flow or pressure of less than 5 psi.

(1) Bearing cages must not show excessive wear.

(2) There must be no evidence of ball or roller skidding.

(3) There must be no evidence of adverse effects due to overheating as indicated by color, general appearance, and hardness.

(4) Satisfactory bearings may be continued in use, otherwise they must be replaced.

16. No. 6 Bearing Support Rod

(1) If for any reason one or more No. 6 bearing support rods are broken an overhaul type inspection of the front compressor drive turbine shaft shall be made.

17. Limits of Acceptability for Diffuser Case

A. Cracks at the weld junction between struts and diffuser case outer skin may be repaired without disassembling engine provided following limits are met.

(1) Cracks must not exceed six inches.

(2) Not more than one crack is permitted at each of seven strut locations. No crack or repair is permitted at gearbox tower shaft strut.

ENGINE - INSPECTION/CHECK

(3) A crack weld repair that redevelops cracks may be repaired by rewelding. See Engine - Approved Repair.

B. Water Injection Bosses

(1) Cracks around water injection bosses may be repaired. See Engine - Approved Repair.

C. Diffuser Case Inner Mount Lug Bushing (P/N 524323)

(1) If outer face of flange on bushing shows a wear step of 0.002 inch or more, replace bushing and mating fuel manifold inner mount bushing. (See Section 73-5-1, Inspection/Check for replacement of fuel manifold bushing.)

D. Fuel Manifold Lock (P/N 524325)

(1) If fuel manifold lock shows a 0.002 inch or more wear step, replace it and mating fuel manifold inner mount bushing. (See Section 73-5-1, Inspection/Check for replacement of fuel manifold bushing.)

18. Periodic Inspection of Installed First Stage Fan Spacer.

(1) P/N 431119 spacer assembly must be inspected at successive 600 hour intervals (625 hours maximum) using either fan spacerscope or ultrasonics for life of part.

(2) P/N 431119 spacer assembly reoperated and reidentified to P/N 522094 in accordance with SB 747 must be given two successive inspections at 600 hour intervals (625 hours maximum) using ultrasonics. If no cracks are found, it will not be necessary to accomplish the next (installed) inspection until 1,200 hours later. If no cracks are found at this inspection, no further (installed) inspection between overhauls will be required for life of spacer.

NOTE: If a one hundred percent ultrasonics bench inspection in accordance with overhaul manual was accomplished on P/N 522094 spacer assembly after reoperation, no periodic (installed) inspections are required between overhaul.

(3) If fan spacerscope inspection rather than ultrasonics is used on P/N 522094 spacer assembly, then assembly must be inspected at successive 600 hour intervals (625 hour maximum).

(4) If cracks are found during any of the above inspections, spacer must be discarded.

19. Tubes

A. Inspect all engine tubing, except where special instructions apply, for the following:

(1) Scratches

(a) Minor scratches having no appreciable depth are acceptable. A scratch, obviously produced by a cutting medium not greater than 0.003 inch deep shall be acceptable. Scratches to a maximum depth of 0.005 inch should be blended out.

(2) Nicks and Chafing

(a) Nicks and chafing are acceptable after blending provided three-quarters of the wall thickness remains. Each blended area must not exceed one half square inch.

(3) Dents

(a) All dents without sharp edges or corners are acceptable provided there is no flow restriction.

(b) No dents are permissible within 1/4 inch of ferrule.

(4) Pitting

(a) Minor isolated pitting is allowable providing pitting is not greater than 0.003 inch deep. Clusters of pitting should be blended out to a maximum of 0.005 inch deep.

(5) Corrosion

(a) Rust and stain shall be acceptable if removable by light polishing with crocus cloth.

20. Turbine Exhaust Fairing Bushing Wear

See Figure 632.

A. Wear Limits

(1) Maximum acceptable wear is 0.015 inch on OD.

(2) Reject any parts worn over maximum amount.

(3) Replace bushings in accordance with Overhaul Manual Section 72-54-2, Repair.

21. No. 6 Bearing Oil Tube Heatshield Or Exhaust Strut Guide Wear

See Figure 632.

A. Wear Limits

(1) Maximum acceptable wear is 0.015 inch on OD.

(2) Repair per Overhaul Manual Section 72-54-17 or 18.

22. Fairing Bushing To No. 6 Bearing Oil Heatshield Or Exhaust Strut Guide Clearance

See Figures 632 and 633.

A. Wear Limits

(1) Maximum acceptable clearance between bushings and oil tube heatshield is 0.030 inch.

(2) Procedures for checking wear.

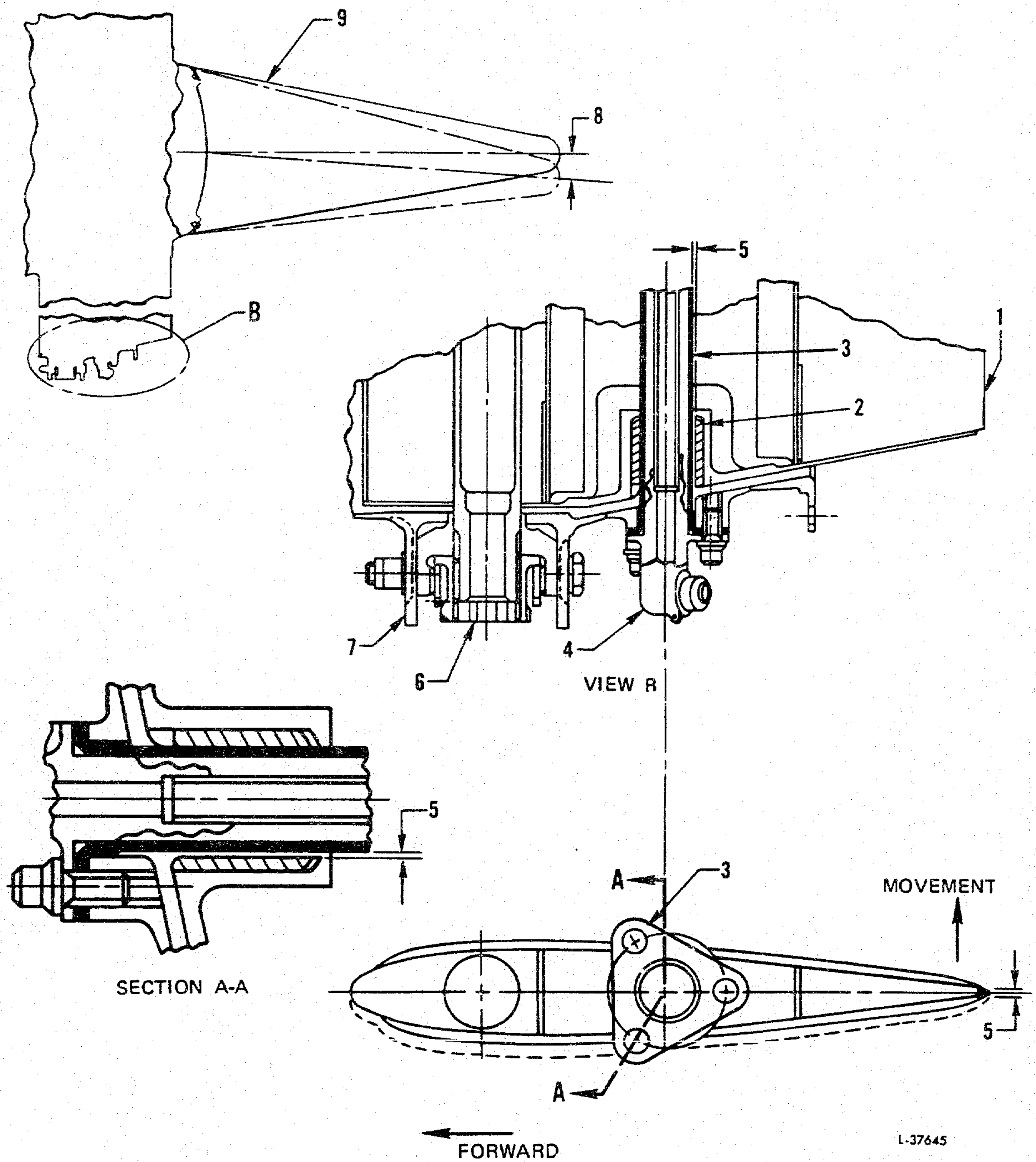
(a) Check relative movement between each vane on exhaust case by securing a dial indicator to exhaust case as shown in Figure 633.

(b) As on alternate to Step (a), measure relative movement trailing edge of turbine exhaust fairing. See Figure 632. Maximum acceptable movement at top of tail cone is 0.050 inch in horizontal or vertical directions. This indicates a heatshield or guide clearance of approximately 0.030 inch.

23. Fireseal - Boeing Installation

A. Cracks In Fireseal

(1) Inspect lower fireseal assembly for circumferential cracking in six o'clock area, outboard of bolt circle. Cracks up to 15 inches in length are reparable. See Approved Repair. Parts with cracks in excess of 15 inches can be salvaged by repair per Overhaul Manual.



Turbine Exhaust Fairing
Bushing Wear Check

Figure 632

1. Turbine Exhaust Fairing (Trailing Edge).
2. Bushing
3. No. 6 Bearing Tube Heatshield.
4. No. 6 Bearing Oil Scavenge Tube.
5. 0.030 Inch (Approx.) When Maximum Movement Is Reached (Typical Four Places).
6. No. 6 Bearing Support Rod.
7. Turbine Exhaust Case.
8. 0.050 Inch Maximum Acceptable Movement At Tip Of Tail Cone.
9. Tail Cone (Typical).

Key To Figure 632

23A. Inspection After Ingestion Of Volcanic Ash

CAUTION: ENGINE INGESTION OF VOLCANIC ASH CAN CAUSE OPERATIONAL PROBLEMS INCLUDING LOSS OF POWER. EVEN IF PROBLEMS ARE NOT EXPERIENCED IMMEDIATELY, ASH CONTAMINATION OF ENGINE SYSTEMS CAN RESULT EVENTUALLY IN PERFORMANCE DETERIORATION, BLOCKED COOLING AIR PASSAGES, AND ABRASIVE DAMAGE.

A. When engine has experienced no operational problems subsequent to volcanic ash exposure, perform the following:

(1) Visually check engine inlet and exhaust areas for evidence of damage or excessive erosion.

(2) Borescope inspect high pressure compressor and high pressure turbine for evidence of the following.

(a) Excessive erosion

(b) Foreign object damage (FOD)

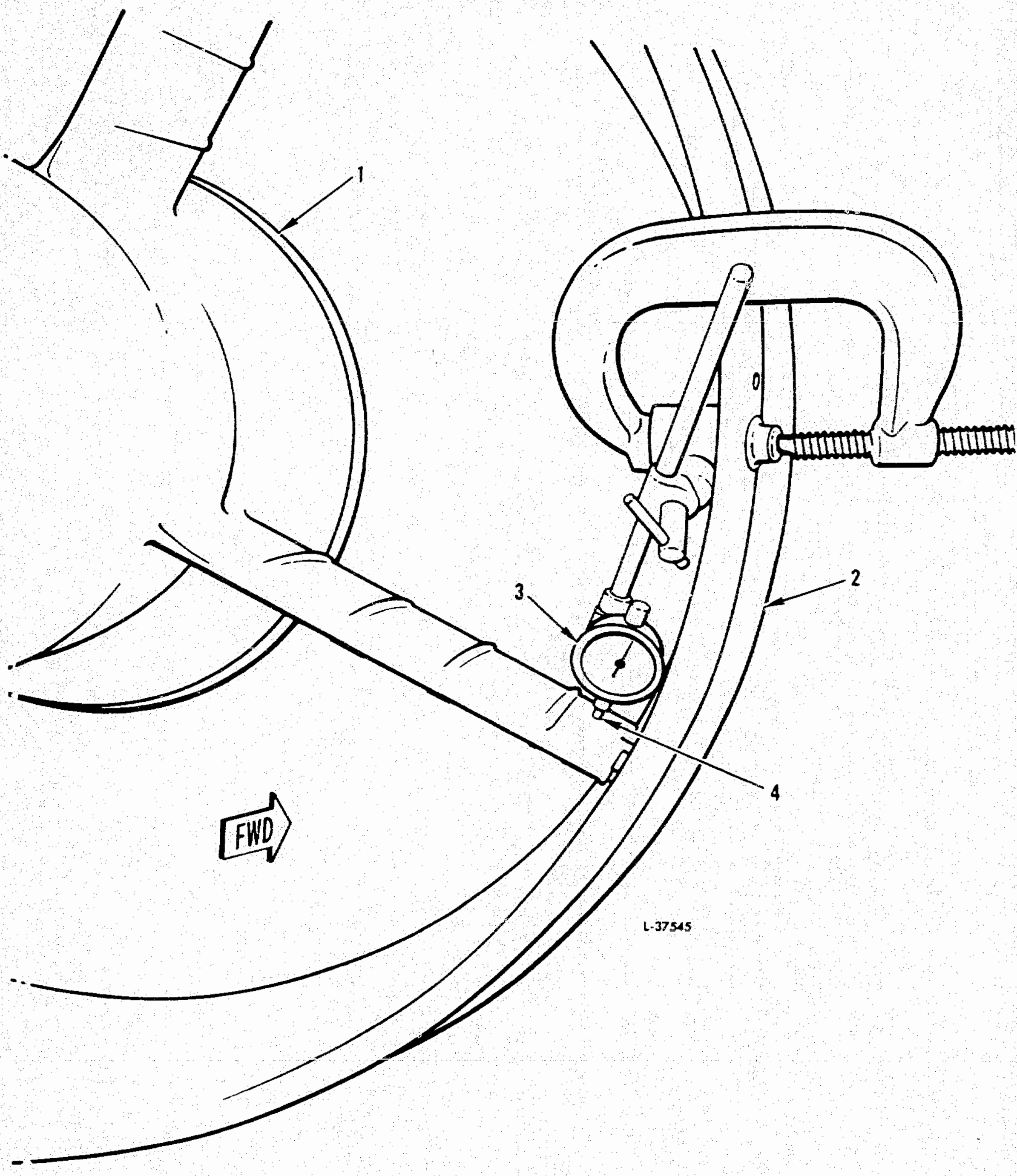
(c) Blockage of H.P. turbine airfoil cooling holes

(d) Build-up of ash deposits

(3) Remove chip detectors and examine for indications of engine damage.

(4) Drain, flush, and refill engine oil system. Retain oil sample for analysis.

ENGINE - INSPECTION/CHECK



1. Turbine Exhaust Fairing (Front).
2. Turbine Exhaust Case.
3. Dial Indicator.
4. Gage Contact Point At Centerline Of Fairing Bushing.

Turbine Exhaust Fairing
Bushing Wear Check

Figure 633

ENGINE - INSPECTION/CHECK

(5) Remove and clean or replace all oil, fuel, and air filters. If contamination is found, retain sample for analysis.

NOTE: It is recommended that a 15 micron main oil filter element be installed if available. If not, oil change frequency should be increased.

(6) Ground run the engine to determine if a shift in performance parameters has occurred. If parameters are abnormal, engine should be replaced.

B. When engine has experienced operational problems subsequent to volcanic ash exposure, perform the following:

(1) Remove engine and route to disassembly facility.

NOTE: Engine records shall direct that engine be disassembled, inspected, and repaired, as necessary, paying particular attention to oil system, air-supplied components and turbine cooling passages.

24. Numerical Tool List

PWA 17205 Support

PWA 30018 Gage

PWA 30455 Probe
(Superseded by PWA 30518)

PWA 30458 Probe

PWA 30471 Probe

PWA 30518 Probe
(Supersedes PWA 30455)

PWA 30973 Template

PWA 30974 Template

PWA 31052 Gage

ENGINE CLEANING

CAUTION: DO NOT CLEAN ANY DIFFUSED NICKEL-CADMIUM PLATED SURFACE WITH AN ABRASIVE MATERIAL.

1. Main Oil Filter Housing

(1) Remove excessive oil by vapor degreasing.

(2) Immerse in carbon remover (cold type) for approximately one-half to one hour and repeat if necessary.

(3) Rinse in hot water.

(4) If necessary, clean by petroleum solvent spray.

2. Main Oil Filter Element Assembly

A. Main Oil Screens and Spacers

NOTE: Prior to cleaning, examine the screens and spacers for the presence of foreign matter which would indicate any unusual condition in the engine. Save the foreign matter and call it to the attention of proper personnel.

(1) Slide the screens and spacers on a suitable rod provided with stops to prevent the screens and spacers from sliding off during cleaning operations.

(2) Loosen the screens from the spacers by sliding the parts along the rod and immerse them for a few minutes in carbon remover (cold type).

(3) Rinse the parts in petroleum solvent and blow them dry with an air jet.

(4) Examine the parts for cleanliness and repeat the cleaning operations if necessary.

B. Main Oil Filter Cover and Oil Scavenge Pump Inlet Strainer

(1) Remove excessive oil by vapor degreasing.

(2) Immerse in carbon remover (cold type) for approximately one-half to one hour and repeat if necessary.

(3) Rinse in hot water.

(4) If necessary, clean by petroleum solvent spray.

3. Cleaning Flexible Tubes

(1) Remove all caps.

ENGINE - CLEANING

(2) Clean the tubes by spraying with petroleum solvent, using a brush, if necessary.

(3) Drain the tubes thoroughly and remove all excess fluid with compressed air making absolutely certain no foreign material remains in the tubes.

(4) Reinstall caps.

4. Cleaning Steel Tubes

(1) Remove all caps.

(2) Clean steel tubes per following procedure.

(a) Soak tube in cold carbon solvent (SPMC 9031, 9047, or 9084) for two hours at room temperature.

CAUTION: BE ABSOLUTELY SURE NO PART OF SWAB OR CLOTH REMAINS INSIDE AN OIL TUBE OR ELSE OIL FLOW CAN BE OBSTRUCTED.

(b) Remove tube from solvent and pull a suitable size swab (or clean lint-free cloth) through inside of tube.

(c) Rinse thoroughly with petroleum solvent (SPMC 9010) at room temperature.

(d) Air dry.

(3) Reinstall caps.

5. Procedure for Cleaning Engine Air Passages

A. General

(1) Field cleaning of the air passages is intended for use on engines displaying definite evidence of performance deterioration due to accumulation of foreign material deposits on compressor blading. Deterioration due to this cause may be detected by repeated necessity to increase high pressure rotor (N_2) speed in order to attain the necessary part power P_{t7} value. If after complying with the necessary procedures outlined in the test section and after field cleaning the engine, the N_2 speed is still over the maximum value, send the engine to overhaul.

B. Cleaning Agent

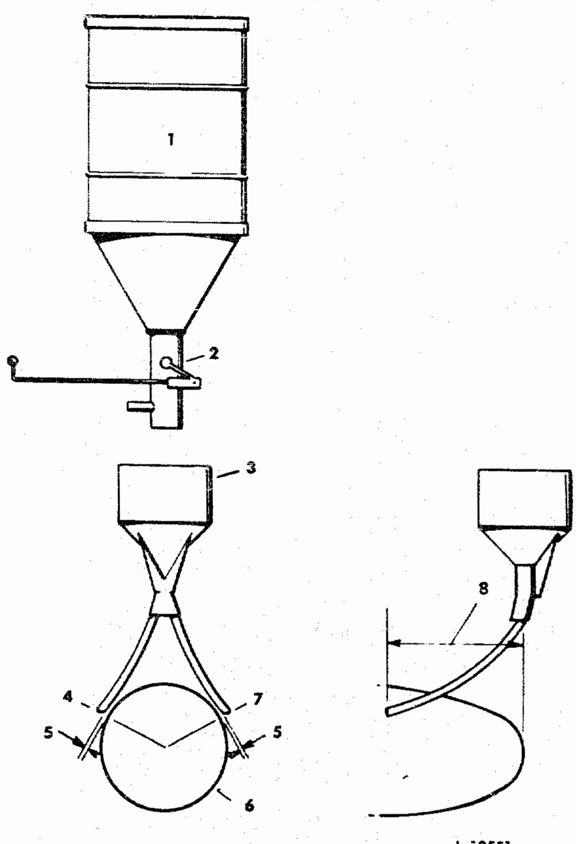
(1) The material approved by Pratt & Whitney for use as the cleaning agent in the field cleaning process is "Carboblast-Jet Engine Type" (PMC 3010). "Carboblast" is manufactured by Turco Products Inc., Los Angeles, California. It is important to note that there is a standard form of "Carboblast" which contains a sufficient amount of rock to be considered totally unacceptable.

ENGINE - CLEANING

CAUTION: IF THE CLEANING PROCEDURE IS DONE WITH THE ENGINE IN THE AIRFRAME, IT WILL BE NECESSARY TO REMOVE FROM THE AIR INLET DUCT OF THE AIRFRAME, ANY COOLERS AND INSTRUMENTATION WHICH MAY BE DAMAGED BY PASSAGE OF CLEANING MATERIAL.

C. Procedure

(1) Fabricate a drum of about 55 gallon capacity with a funnel outlet incorporating a sliding sheet metal valve, and a shut off valve. Attach a hopper, with two outlets of 3/4 inch tubing, to the drum with four lengths of chain. The complete equipment will then approximate the illustration shown in Figure 701. Position the equipment above and slightly forward of the engine inlet with the two hopper discharge tubes at the two and ten o'clock positions. Secure the discharge tubes to the inlet duct or to the screen if engine is on a test stand. The end of tubes must be as close as possible to the nose cone, not over 1/4 inch away, in order to keep carbo blast from going out fan discharge area.



1. Drum	3. Hopper	5. 1/4 Inch Maximum	7. 2 O'clock
2. Valve	4. 10 O'clock	6. Fairing	8. 12 to 14 Inches

Carbo-Blast Arrangement

Figure 701

ENGINE - CLEANING

CAUTION: ADJUST THE SLIDE VALVE TO PROVIDE A FLOW OF CLEANING MATERIAL NOT TO EXCEED THE MAXIMUM OF 100 POUNDS IN 15 MINUTES. PERSONNEL USING THIS PROCEDURE SHALL BE CAUTIONED AGAINST INCREASING THE INJECTION RATE OF THE MATERIAL, SINCE AN INCREASED RATE MAY RESULT IN A CONCENTRATION OF THE MATERIAL IN CONFINED AREAS OF THE ENGINE, WHERE A FIRE, WHICH MIGHT CONCEIVABLY DAMAGE ENGINE PARTS, MAY OCCUR. PRIOR TO ACTUAL ENGINE RUNNING, CHECK THE RATE OF DISCHARGE OF CARBOBLAST MATERIAL. RATE OF DISCHARGE WILL VARY CONSIDERABLY DEPENDING ON CARBOBLAST MOISTURE CONTENT.

(2) Remove or disconnect components from the engine in order to avoid damage during the cleaning operation. Complete removal of tubes which bleed air from the compressor is not necessary provided a stainless steel cover plate 0.032 inch thick is installed between the tube and the opening and the bolts tightened. This then blanks off systems which use compressor air and prevents accumulation of cleaning material in other equipment. Remove or blank off the following:

(a) Remove the compressor bleed control temperature bulb and bellows from the front accessory support.

(b) Remove the left and right anti-icing air valves, tubes, compressor bleed valve screen housing, compressor bleed valve actuator supply tubes and water shut-off valve air tube. Remove the pressure sensing tube from the front support case. Remove the two fuel drain valve assemblies from the combustion chamber outer case. Cap the openings in the cases and tube ends.

(c) Disconnect the high pressure compressor bleed manifold and cap the openings.

(d) It is not necessary to remove the pressure probes or the thermocouples from the turbine exhaust case for carboblast cleaning operation. No precautions are required for the thermocouples. 80 to 120 psi air pressure must be applied to the pressure probe manifold during the actual cleaning operation. If the probes or thermocouples are removed, cap the openings.

NOTE: Do not unfasten the compressor discharge pressure tube at the fuel pressurizing and dump valve.

(e) Remove any aircraft instrumentation in the gas path and cover the openings.

NOTE: The above operations are necessary to prevent accumulation of cleaning material in equipment or instrumentation, either engine or airframe mounted, which may cause malfunctioning of the equipment.

(f) Pour 200 pounds of the cleaning material into the drum.

(g) Start the engine; then, after warm-up at 85 percent, open the valve at the drum outlet without reducing power.

CAUTION: ENGINE MUST BE THOROUGHLY WARMED-UP AT 85 PERCENT FOR FIVE MINUTES BEFORE OPENING THE DRUM OUTLET.

NOTE: Provide for manual operation of compressor bleed valve utilizing external air source. Close bleed valve prior to introduction of carboblast and cycle valve every five minutes during process.

(h) Accelerate the engine to approximately 92 percent (Tach) N_2 speed; then slowly decelerate and accelerate between 85 percent and 92 percent (Tach) N_2 speed for a period of five minutes.

(i) Operate the engine at 90 percent to 92 percent (Tach) N_2 speed for five minutes.

(j) Then, repeat the acceleration and deceleration operation described above until the complete 200 pounds of cleaning material is consumed.

NOTE: If the desired P_{t7} cannot be obtained using 200 pounds of cleaning material, the steps outlined above should be repeated using another 200 pounds of cleaning material. The entire process for a single run should take 30 to 40 minutes of engine operation, but not less than 30 minutes.

(k) Run the engine for five minutes at idle; then shut down.

(l) If installed remove the caps and closures which were temporarily installed over the bleed and pressure line opening and operate the engine for five minutes at up to 90 percent N_2 speed; then run the engine for five minutes at idle and shut down.

NOTE: The purpose of this run is to permit any cleaning material accumulated in the bleed ports to be blown out.

CAUTION: MAKE CERTAIN THAT HIGH TEMPERATURE GASES ARE NOT DIRECTED AGAINST COMBUSTIBLE AIRCRAFT EQUIPMENT (SUCH AS WIRE BUNDLES).

(m) Install any aircraft instrumentation removed from the gas path and the high pressure compressor bleed manifold.

ENGINE - CLEANING

(n) Install left and right anti-icing air valves, tube, compressor bleed valve actuator supply tubes and water shut-off valve air tube as complete units.

(o) If removed, install pressure probes and thermocouples in turbine exhaust case.

CAUTION: CARE MUST BE EXERCISED IN INSTALLING FUEL DRAIN VALVES IN COMBUSTION CHAMBER OUTER CASE. PIN HOLE IN VALVE ASSEMBLY MUST BE PROPERLY ALIGNED WITH LOCATING PIN IN CASE.

(p) Install compressor bleed valve control temperature bulb on front accessory drive front support and pressure sensing tube on inlet guide vane and shroud case. Install two fuel drain valves in combustion chamber outer case.

(q) Retrim engine.

6. Liquid Washing of Engine for Performance Improvement

NOTE: Engine performance deterioration, i.e., high power stalls, increase in low and high compressor speed, exhaust gas temperature, and thrust specific fuel consumption, may be due to contamination of blades and vanes of both compressors and turbines. This contamination may be removed by washing with fresh water or optional detergent solution while rotating engine with starter. The following procedure is recommended on a regular basis. However, since environmental conditions vary widely among operators, the frequency of a periodic liquid wash program or the desirability of detergent wash should be determined by each individual operator.

A. Water Wash Procedure

(1) Conduct pre-wash engine performance checks at EPR's of 1.37 (data plate), 1.60 and Take-Off EPR. At each point, operate engine for three minutes, then record N_1, N_2, EGT and fuel flow. For this check, engine air bleed and electrical load extraction shall be zero.

NOTE: Under icing conditions, thermal anti-icing may be used between check points.

(2) Shut down engine and allow at least 30 minutes for engine to cool.

(3) Pull ignition circuit breaker for engine being washed.

ENGINE - CLEANING

(4) Disconnect generator cooling inlet (Aft) supply duct (Boeing).

(5) Ensure that start lever for engine being washed is in "Off" position.

(6) Ensure that all anti-icing air shut-off, fuel de-icing heater shut-off and airframe bleed extraction shut-off valves (except engine bleed valves) are closed.

(7) Make certain N_2 rotation is completely stopped, then engage starter and allow engine to reach full starting rpm. Do not exceed starter duty cycle.

WARNING: IN FOLLOWING SPRAY PROCEDURE, IF HOSE IS HAND HELD, OPERATOR MUST STAND AT LEAST THREE FEET FROM ENGINE INLET.

(8) Using 3/4 inch ID or larger hose, spray clean tap water that is of drinking purity into engine inlet at 35 - 45 psi for 30 seconds while motoring engine with starter. Spray should be directed toward center of engine inlet but not directly at nose cone. Approximately 40 - 50 gallons of water may be discharged into engine in 30 second period.

NOTE: It is permissible to add sufficient alcohol (AMS 3002 or AMS 3004) to water to prevent freezing. Wash mixture of up to 50 percent alcohol may be used. See Tables I and II.

Percent Alcohol By Volume	Outside Air Temperature
3	40°F (4.4°C)
6	38°F (3.3°C)
9	36°F (2.2°C)
14	33°F (0.6°C)
17	31°F (-0.6°C)
20	28°F (-2.2°C)
22	26°F (-3.3°C)
23	25°F (-3.9°C)
27	20°F (-6.6°C)
32	15°F (-9.4°C)
36	10°F (-12.2°C)
39	5°F (-15°C)
43	0°F (-17.8°C)

Minimum Required Ethyl Or Isopropyl
Alcohol To Water Mixture
Table I

ENGINE - CLEANING

Percent Alcohol By Volume	Outside Air Temperature
5	40°F (4.4°C)
10	33°F (0.6°C)
15	27°F (-2.8°C)
20	22°F (-5.6°C)
22	20°F (-6.6°C)
26	15°F (-9.4°C)
29	10°F (-12.2°C)
32	5°F (-15°C)
36	0°F (-17.8°C)

Minimum Required Methyl Alcohol
To Water Mixture
Table II

(9) Turn water off and release starter.

(10) Allow engine to drain for approximately five minutes.

(11) Repeat substeps (7) through (10) as desired (generally two to four times) to obtain incremental improvement in engine surge margin and performance, based on operator's experience.

(12) Inspect inlet guide vanes to ensure that they are undamaged.

(13) Reset ignition system circuit breaker for washed engine. Remove plug from fuel control P_b tube moisture trap and check for entrapped water. Reconnect generator cooling duct.

(14) Conduct post-wash engine performance check at EPR's of 1.37 (data plate), 1.60 and Take-Off EPR. At each point, operate engine for three minutes, then record N_1, N_2, EGT and fuel flow. For this check, engine air bleed and electrical load extraction will be zero. This step should be done immediately after washing engine.

CAUTION: DO NOT EXCEED GROUND STATIC OPERATION LIMITS FOR ANTI-ICING AIR SYSTEM.

(15) If engine is to remain inoperative for four hours or more after washing, start engine and run at idle for five minutes. Operate anti-icing air shut-off, fuel de-icing heater shut-off and applicable airframe bleed extraction shut-off valves.

ENGINE - CLEANING

NOTE: Under very cold and windy weather conditions, even if water/alcohol mixture is used, there is a high probability of ice formation in engine in less than four hours if engine run-up is not performed following wash, to purge or evaporate residual water.

(16) Shut down engine and recheck fuel control P_b tube moisture trap for water.

B. Detergent Wash Procedure (Optional)

(1) Perform substeps (1) through (6) of Water Wash Procedure.

(2) Prepare 20 gallons of detergent solution, composed of 20 percent cleaning agent (four gallons) and 80 percent water of drinking purity.

NOTE: Cleaning agent may be one of following:

Harco 141, from Harley Chemicals, Inc.
17th and Federal Street
Camden, N.J. 08105

B&B 3100, from B&B Chemical Co., Inc.
P.O. Box 796
Miami, Florida 33166

Turco 5884, from Turco Products, Inc.
Division of Purex Corp.
24600 South Main Street
Carson, California 90745

(3) Make following preparations for washing (during cooling period, if desired).

(a) Disconnect P_{t2}, P_{s3}, and P_{s4} lines to pressure ratio bleed control.

(b) Disconnect P_{t2} and P_{t7} lines to engine pressure ratio transmitter at low point on engine.

(c) Disconnect P_b sense line to fuel control at engine.

(d) Disconnect thrust reverser and hydraulic reservoir pressurization line at engine.

NOTE: It is not necessary to cap off fittings after disconnecting lines, providing fittings are offset to prevent water from entering line or unit.

(4) Motor engine with starter at approximately 2500 rpm N_2.

ENGINE - CLEANING

(5) Discharge approximately five gallons of detergent solution into engine and release starter.

(6) Wait 20 minutes, then repeat substeps (4) through (6) three more times.

(7) Immediately water wash engine as directed in Step A., (7) through (10).

(8) Reconnect engine and airframe lines removed in substep (3).

(9) Reset ignition system circuit breaker for washed engine. Reconnect generator cooling duct.

(10) Check fuel control P_b tube moisture trap for water and perform performance calibration run as directed in Step A., (14) through (16).

C. Water Wash Procedure (Routine Use Version)

(1) This procedure is virtually identical to Step A., with exception that pre-wash, substep (1), and post-wash, substep (14), engine performance checks are not required. Operators who choose to follow a routine water washing schedule may use this procedure as a means of minimizing gaspath contamination or retarding turbine airfoil sulfidation.

ENGINE - APPROVED REPAIR

1. General

A. Refer to Disassembly/Assembly section for information concerning standard engine maintenance practices.

B. Refer to Chapter 71, as required, for information concerning removal of airframe installed parts.

2. Combustion Chamber Outlet Duct

A. Anti-Rotation Lug (PN 570721)

(1) Anti-rotation lug that is bent and does not extend out through center slot of duct flange may be repaired as follows:

(a) Tap end of lug, where it is welded to outer duct wall, to rotate outer wall and slip outer end of lug into center slot of duct flange. Straighten lug in center slot of flange as outer wall is slipped (rotated) back into position.

3. Compressor Inlet Case (For Cases PN 502337, 515226, 633682)

A. Stripped Attaching Bolt Hole Threads - Rear Outer Flange

NOTE: This is an "on wing" repair. See Overhaul Manual, Repair Section 72-21-1 for disassembled weld repair.

(1) Install Heli-Coil as shown on Figure 801.

(2) Remove damaged material front flange by using drill size Q.

(3) Plug tap each hole using Heli-Coil Tool 1193-5.

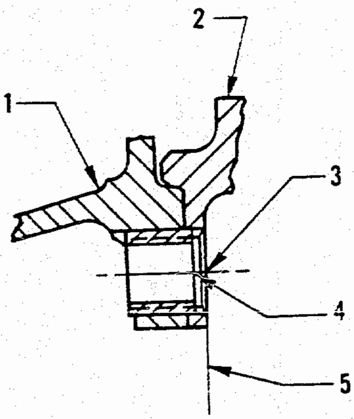
NOTE: Tools specified are proprietary items, it is suggested they may be purchased from Heli-Coil Corporation, Danbury, Connecticut.

(4) Check threads in each hole using Heli-Coil thread gage 3694-5.

(5) Install insert MS 124657 in inserting tool, Heli-Coil 535-5, and install insert in threaded hole.

(6) Remove inserting tool and break off tang to notch, using Heli-Coil break off tool 1196-5.

ENGINE - APPROVED REPAIR



VIEW SHOWING THREAD REPAIR

L-31927

1. Rear Flange Compressor Inlet Case.
2. Front Flange Fan Case.
3. Thread For 0.3125-24 Helical Coil Insert Chamfer 120° ± 5° Inclusive To 0.360 - 0.400 Diameter.
4. MS 124675 Insert As Required.
5. Top Face Of First Coil To Be 0.75 To 1.00 Pitch Below This Surface, Break Off Tang At Notch.

Compressor Inlet Case Helical
Insert Repair
Figure 801

ENGINE - APPROVED REPAIR

B. Heat Sensitive Paint Application

NOTE: Application of heat sensitive paint provides a method of detecting failed anti-icing regulators by monitoring temperature of anti-icing air circulating through inlet vane and shroud assembly.

(1) Clean vanes with grease dissolving cleaning fluid and prepare surface with silicone carbide cloth. See Figure 801A for locations of vanes to be painted.

(2) Apply brush coat of Merkens TW Undercoat White, Grade No. 45.0050. Paint should cover a 0.500 inch diameter area and should be applied on those vanes adjacent to anti-icing inlet area near OD of vane. See Figure 801A.

(3) Allow paint to dry for four hours.

(4) Apply brush coat of Merkens TW Color Changing Paint, Grade No. 45.0005, to areas coated in step (2).

(5) Allow paint to dry for four hours.

4. Welded Braces To Reinforce Rear Outer Flange

NOTE: This is an "on wing" repair. See Overhaul Manual Repair Section 72-21-1 for disassembled weld repair.

A. Procedure

(1) Weld as shown on Figure 802.

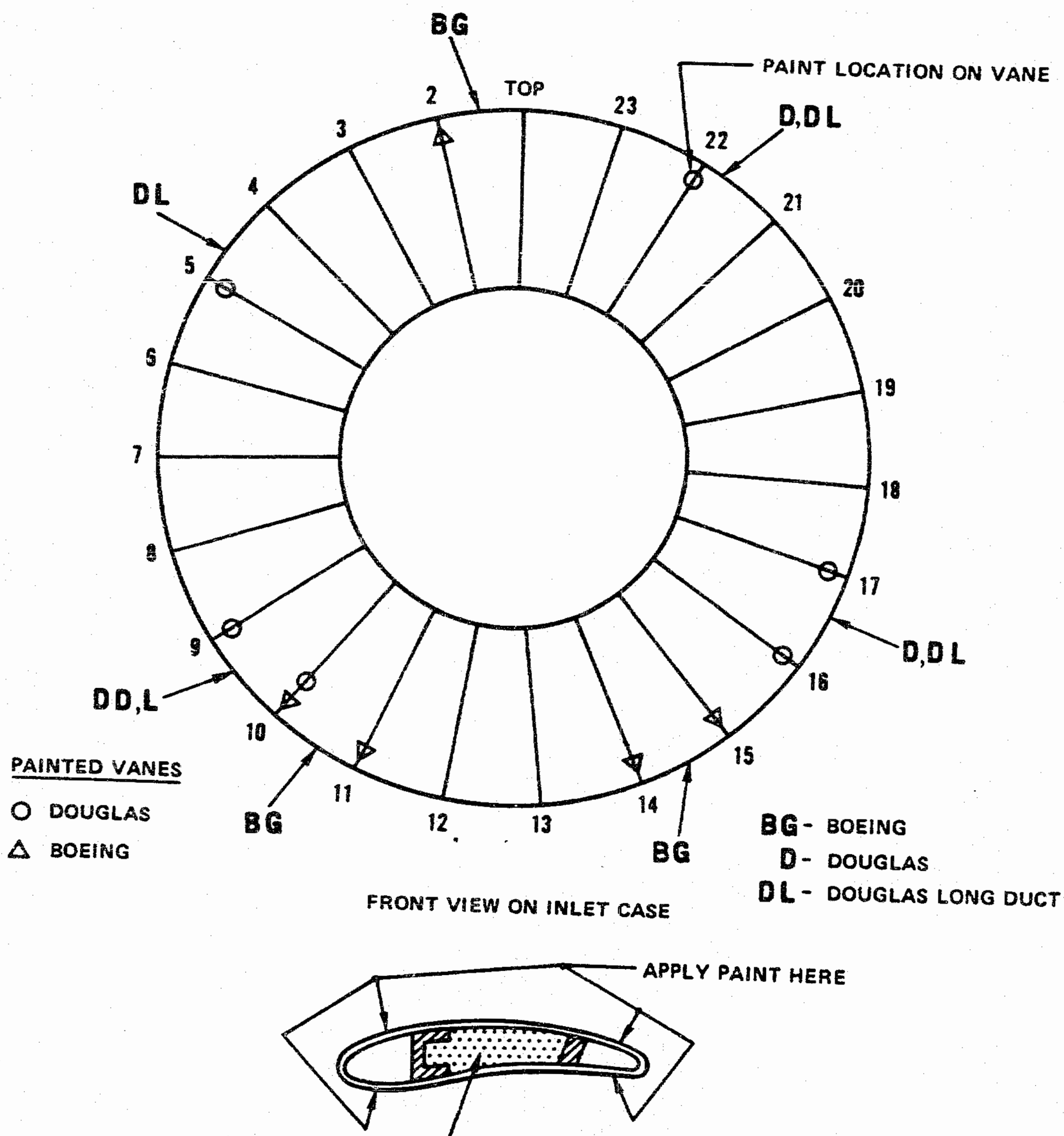
(2) Stress relieve not required for this repair.

5. First Stage Fan Blade On Wing Repair And Flyback Limits

NOTE: First stage fan blades which have foreign object damage in excess of inspection and repair limits shown in Figure 601, INSPECTION/CHECK section may be continued in service by performing on wing repair as indicated below.

ENGINE - APPROVED REPAIR

JT3D ANTI-ICING INLET LOCATIONS



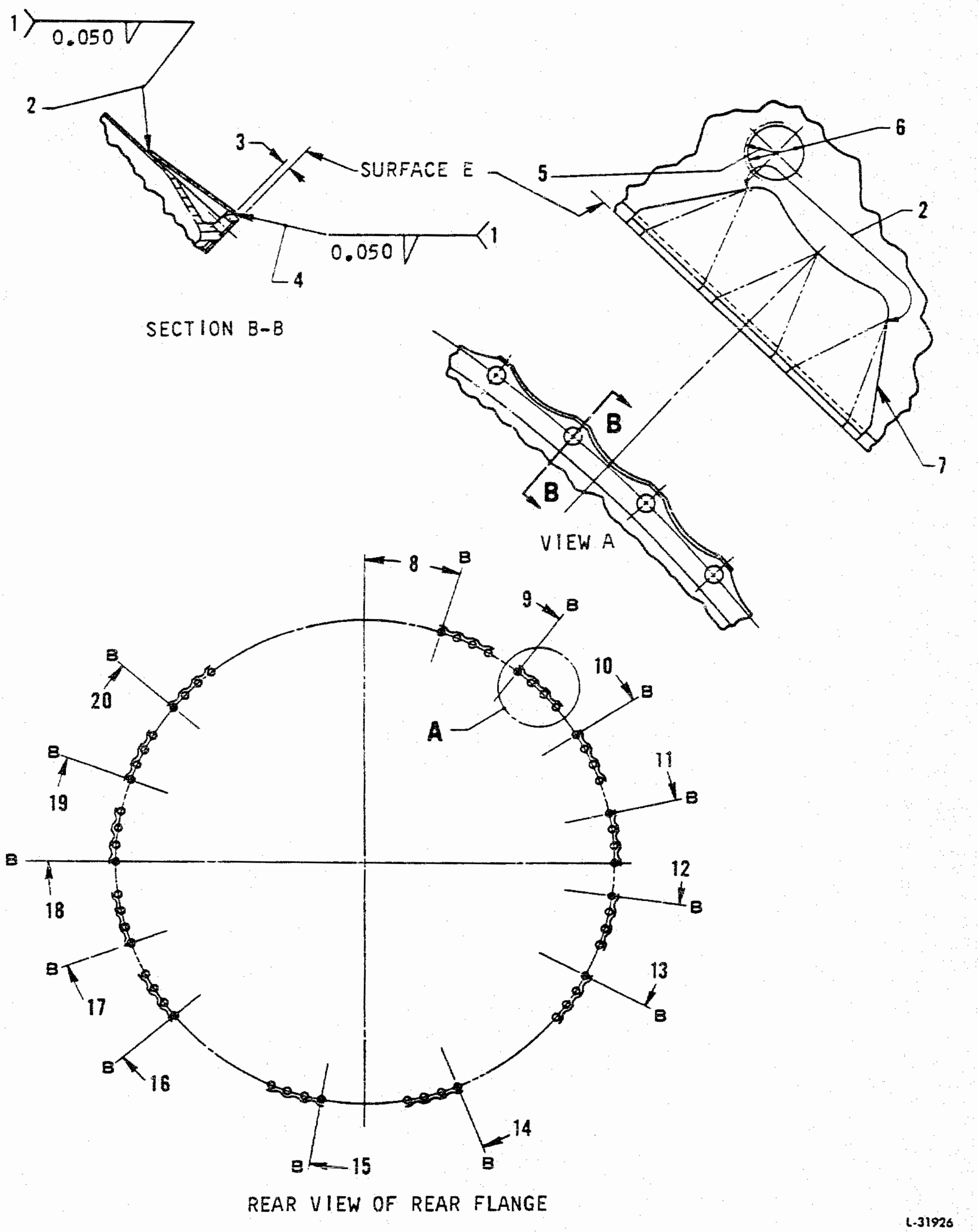
FRONT VIEW ON INLET CASE

SECTION THROUGH VANE

L-59132

Locations For Application Of
Heat Sensitive Paint
Figure 801A

ENGINE - APPROVED REPAIR



Compressor Inlet Case Rear Flange
Reinforcement - Welded Braces

Figure 802

ENGINE - APPROVED REPAIR

1. Weld Using AMS 4951 Filler Metal, Machine Gas Tungsten - Arc (TIG) per Standard Practices Manual.
2. Weld For This Distance.
3. 0.140 - 0.160 Inch
4. Weld Along Contour.
5. 0.531 - 0.594 Inch Radius - If Necessary, Brace May Be Finished To This Dimension To Prevent Overlapping Diameter No. 6.
6. 1.028 - 1.048 Inch Diameter - Reference
7. Brace PN 692736, Required At Locations B.
8. 18° Reference
9. 38° Reference
10. 58° Reference
11. 78° Reference
12. 98° Reference
13. 118° Reference
14. 158° Reference
15. 190° Reference
16. 230° Reference
17. 250° Reference
18. 270° Reference
19. 290° Reference
20. 310° Reference

Key to Figure 802

A. Procedure

(1) Repair leading edge outer end of blade within limits and cuts given in Figure 803.

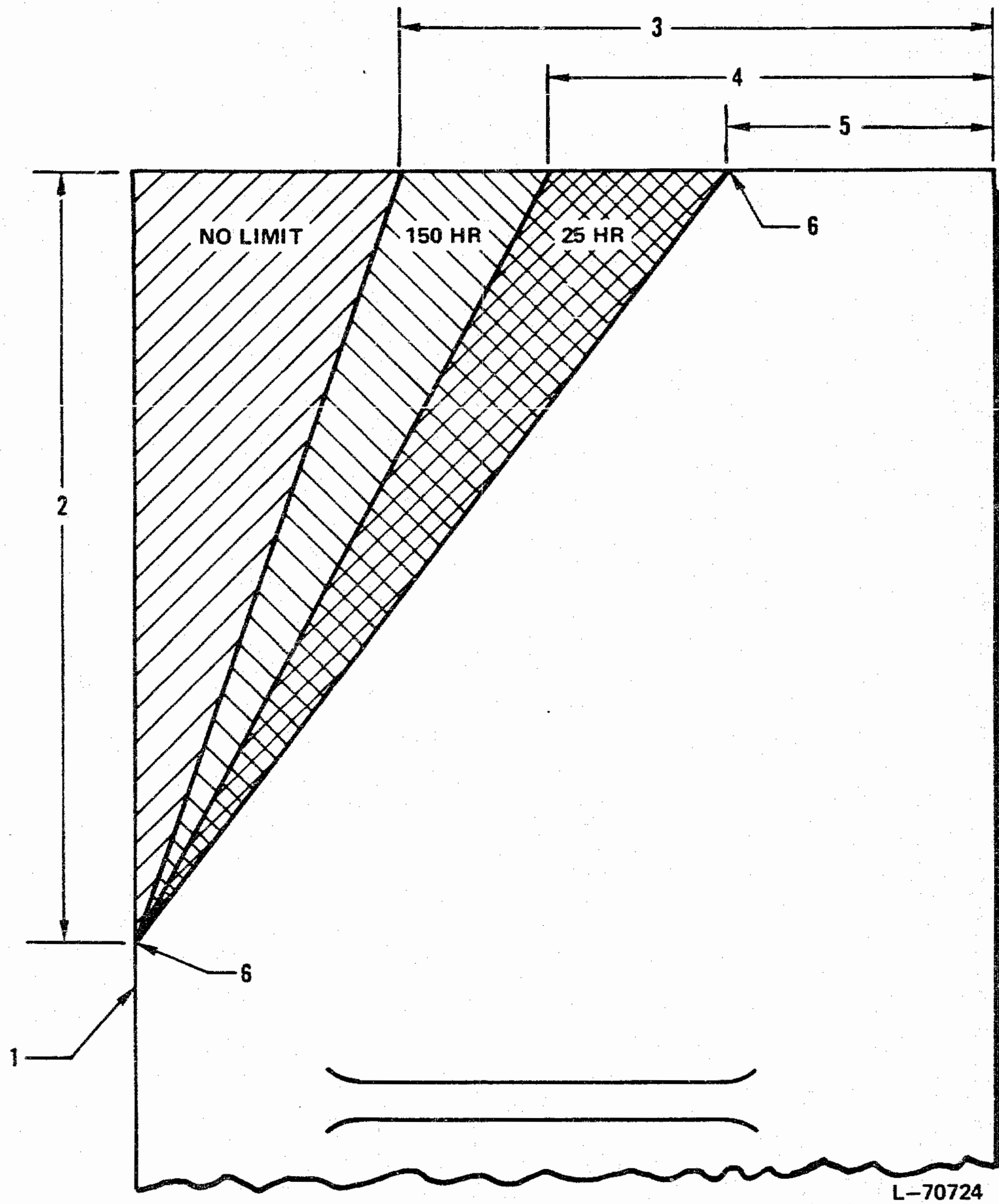
(a) Do not repair more than a total of 6 blades per rotor to any cut or combination of cuts in Figure 803. Reworked blades may be adjacent or scattered throughout the rotor assembly. However, any individual blade incorporating the dimensions of either the 25 or 150 hour cut-back will restrict the time on that rotor to 25 or 150 hours as applicable. Should all six blades be repaired to the dimensions of the 25 hour flyback cut, the following performance penalty may exist:

1 Decrease in fan efficiency of approximately 5 percent.

2 Decrease in fan operating line of 1.2 percent.

3 Decrease in fan flow capacity of 0.8 percent resulting in a 1.2 percent thrust loss.

ENGINE - APPROVED REPAIR



1. Leading Edge
2. 4.50 Inches
3. 3.35 Inches
4. 2.50 Inches
5. 1.50 Inches
6. Smooth Blend

First Stage Fan Blade On Wing
Repair And Flyback Limits
Figure 803

ENGINE - APPROVED REPAIR

4 Increase in TSFC of 2 percent due to thrust loss.

(2) Remove damage with a hacksaw or other suitable hand tool. Insert piece of scrap sheet stock between blade tip and fan case.

CAUTION: AREA TO BE REWORKED WITH CUT-OFF WHEEL MUST BE COMPLETELY MASKED TO ENSURE THAT NO METAL SPLATTER CAN STRIKE ANY OTHER BLADE OR DISK SURFACE.

(3) Using a two inch diameter cut-off wheel, remove major portion of material to be removed.

NOTE: A minimum of 0.060 inch material must remain for hand filing and polishing to assure removal of any heat affected area.

(4) Use a Norton A601-OBNA2, Type I, Shape GWI(A) (2x1/32x1/4 inch) cut-off wheel or equivalent in an ARO air chuck, model 7015S, which has an operating speed of 18,000 rpm maximum. A 3/16 inch rotary file may be used as an alternate tool to cut-off wheel.

(5) Hand file and polish leading edge where cut has been made.

(6) Finish all edges of repair area to form a well-rounded radius with a smooth surface.

(7) Inspect repaired blades as outlined in Inspection/Check section.

(8) Flyback cut must not create excessive imbalance and vibration in operation.

6. Front Compressor Case and Vane Assembly

A. Procedure

(1) Gas Tungsten Arc weld cracks in area of anti-icing air ports using AMS 5776 filler metal.

(2) Locally stress-relieve weld repaired area per Cycle 1A as follows:

(a) Heat to 600°F (316°C) and hold for 30 minutes.

(b) Increase to 800°F (427°C) and hold for 30 minutes.

(c) Increase to 1015° ±15°F (546° ±8°C) and hold for two hours.

(d) Cool to 500°F (260°C) not faster than 100°F (56°C) every 15 minutes.

ENGINE - APPROVED REPAIR

7. Tubing Patch Repair

A. Suggested Flyback Repair Procedure For External Tubing.

CAUTION: TUBES REPAIRED IN THIS MANNER SHALL BE REPLACED AFTER FLYBACK.

NOTE: This repair does not include high pressure fuel lines: main pump to fuel control, fuel control to fuel oil cooler, fuel oil cooler to pressurizing and dump valve and pressurizing and dump valve signal line.

(1) See Table II for repair procedure.

(2) Use AMS 5510 SST for patch doubler material and AMS 5570 for sleeve doubler material.

(3) Edge of patch shall not extend into tube bend.

(4) Repair within 0.250 inch of a ferrule.

(5) Minimum overlap of repair area 0.250 inch.

(6) Braze per Standard Practices Manual, using AMS 3411 flux.

ENGINE - APPROVED REPAIR

TYPE OF DAMAGE	ACCEPTABLE DAMAGE	METHOD OF REPAIR	REPAIR PROCEDURE
Dents (Distorted wall, no thickness reduction).	1. No sharp edges 2. Free passage of ball 80% ID of tube 3. Not within 0.250 inch of ferrule	Doubler repair	1. Straighten tube to acceptable limits 2. Doubler repair: A. Patch doubler for repair area up tp 25% of tube OD wide and 50% of tube OD long. B. Sleeve doubler for repair area up to 50% of tube OD wide and 3x tube OD long.
Nicks-(scratches, sharp edges, gouges).	Minor scratches and pitting not exceeding 0.003 inch deep	Blending or or doubler repair	1. Blending: A. Blend out to maximum depth of 0.005 inch. B. 75% wall thickness must remain after blending. C. Blend area must not exceed exceed 0.50 square inch. 2. Doubler repair: (Same as dents).
Wear (thin areas, clamps etc).	Wear up to 0.003 inch deep	Doubler repair	1. Doubler repair: A. Same as dents except sleeve doubler under all clamp and clip areas.
Holes (worn, punched, or open cracks).		Doubler repair and fusion weld repair	1. Doubler repair: (same as dents) 2. Fusion weld repair: 0.025 maximum width, length to 1/2 tube diameter maximum circumference 25% tube diameter, 100% penetration, underbead cannot exceed 25% wall thickness under 2 inch diameter, 10% over 2 inches diameter.

Table II

(7) See Figure 804 for typical repair procedure.

(8) Pressure test

(a) Up to 0.500 OD at 700 psi

(b) Over 0.500 to 0.750 OD at 500 psi

(c) Over 0.750 to 1.000 OD at 300 psi

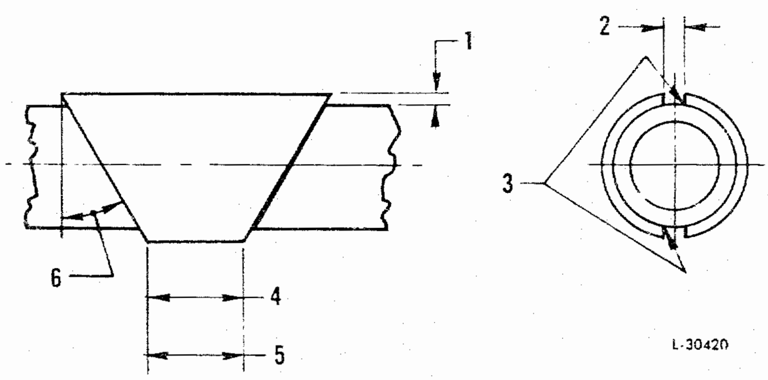
8. First Stage Fan Blades (Titanium) Blend Repair

A. Procedure

(1) Minor injuries to first stage fan blades (titanium) can be repaired provided the injury can be removed without exceeding allowable limits in Figure 601.

(a) A minimum blend equal to four times the depth of repair must be maintained on all blade blend repairs.

CAUTION: NICKS IN THE LEADING AND TRAILING EDGES BECOME INCREASINGLY CRITICAL THE CLOSER THEY ARE TO THE BLADE ROOT.



1. 0.030 Inch
2. Gap Permissable - Two Places
3. Silver Braze Using AMS 3411 Flux Per Standard Practices Manual.
4. 0.250 Inch Minimum
5. 1.000 Inch Minimum Under Clip Or Clamp.
6. 30° Approximately - 4 Places

Doubler Repair Procedure
Figure 804

(b) Do not attempt to remove any injury by straightening.

CAUTION: THE LIMITS REFERRED TO IN FIGURE 601 IN AREAS "C", "E" AND "F" PERTAIN TO LOCAL, ISOLATED, DAMAGED AREAS ONLY AND MUST NOT BE INTERPERTED AS AUTHORITY FOR REMOVAL OF MATERIAL ALL ACROSS THE TIP AND LEADING OR TRAILING EDGES AS MIGHT BE DONE IN A SINGLE MACHINING CUT.

(c) Check surface finish of the flameplated area of the midspan shroud of first stage blades. Surface finish must be at least 80 rms. If not within limits stroke flameplated area 10 or 15 times with 180 grit aluminum oxide cloth. Recheck surface finish.

(2) Blend blades in accordance with the following procedure.

CAUTION: DENICKING AND BUFFING OF TITANIUM MUST BE DONE IN STRICT ACCORDANCE WITH THESE INSTRUCTIONS TO AVOID BURNING. DO NOT USE BELT TYPE SANDERS. BECAUSE OF DIFFICULTY IN HANDLING SMALL PARTS, AND INCREASE POSSIBILITY OF BURNING, TITANIUM COMPRESSOR BLADES WITH AN AIRFOIL LENGTH OF LESS THAN ONE AND THREE-QUARTERS OF AN INCH SHALL NOT BE REPAIRED BY POWER TOOLS.

WARNING: TITANIUM PARTS MUST NOT BE REWORKED ON EQUIPMENT INCORPORATING A WATER-WASH DUST COLLECTOR THAT IS USED TO REWORK STEEL PARTS. CLEAN UP TITANIUM DUST AT LEAST ONCE A DAY. DO NOT ALLOW TITANIUM DUST TO ACCUMULATE ON CLOTHING. AN ACCUMULATION OF TITANIUM DUST IS A FIRE HAZARD.

(a) Remove nicks, scratches or pits and radius sharp edges on parts by blending on polishing lathe with small wheel such as Carborundum Co. No. C36-P-BFX2 or equivalent using minimum wheel pressure. Do not operate at an arbor speed of more than 3,000 rpm.

(b) Blend out wheel marks, light nicks, scratches, pits and radius sharp edges on polishing lathe using cloth wheel (two sections) coated with adhesive precoat PMC-3091 and polishing compound PMC-3048.

NOTE: Use only minimum pressure when applying a part to wheel to avoid overheating. Use maximum of 2,400 rpm.

(c) Buff reworked areas using 12 inch diameter tampico brush and burring polishing compound PMC-3061, at 2,400 rpm maximum. Buff part so all polishing lines are parallel with length of airfoil, never across it. Maintain surface finish in repaired area as nearly comparable to new part as possible.

(d) Wipe part with soft cloth to remove residual polishing compound or other foreign material.

(e) Inspect repaired parts with portable fluorescent penetrant inspection method.

9. Fan Discharge Case Fairing

A. Tapped Holes - Helical Coil Reoperation

See Figure 805.

(1) If threaded hole(s) are damaged, rework to bring acceptable condition by installing a helical coil insert. See Referenced figure.

(2) Clean per SPOP 203.

NOTE: Reidentify to PN 701773.

B. Tapped Hole Rework

See Figure 805.

(1) Rework holes as per referenced figure. Clean per SPOP 203. Reidentify to PN 701773.

(2) Use PN 701774 at installation.

10. Replacement of No. 6 Bearing Oil Pressure (Inner) and Oil Scavenge (Inner) Tube Assemblies

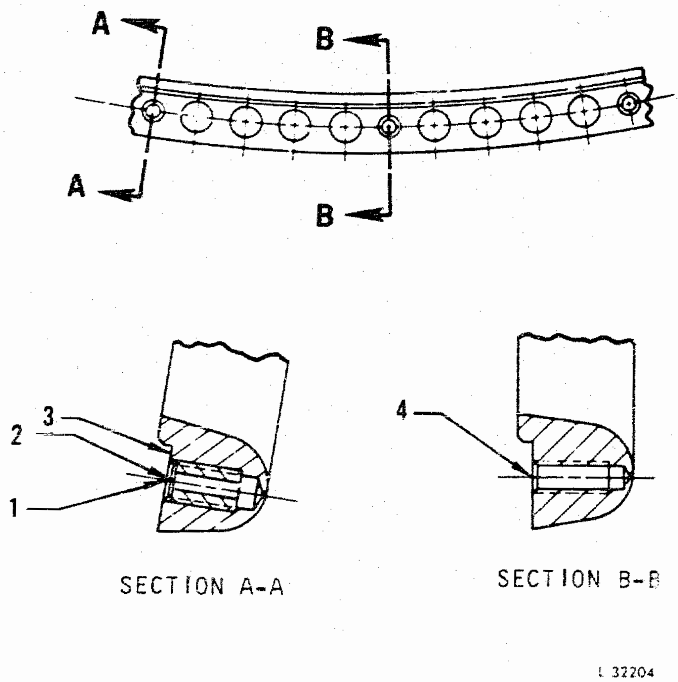
A. Procedure

(1) Remove turbine exhaust cone assembly.

(2) Unfasten screws and remove No. 6 bearing oil sump heatshield.

(3) Unfasten coupling nuts at both ends of inner oil tube assemblies using PWA 30634 Wrench on wrenching hex on outer oil tubes to prevent transmitting torque load through tubing.

NOTE: For engines incorporating guides, PN 654472, reference SB 2081, unfasten guides from brackets attached to sump assembly and slide guide down sleeve away from inner oil tube so wrenching hex is acceptable.



For Repair Of Damaged Threads (Section A-A)

1. Thread For 0.190-24 Helical Coil Insert Minor Diameter Depth 0.487 Inch Maximum. Drill Point 160° Minimum, Including Chamfer 120° ± 5° Included To 0.240 - 0.280 Diameter Minimum, Full Thread Depth 0.330 Inch.
2. MS122120 As Required. Before Assembling, Coat Mating Threads Of Insert And Fairing Per AMS 3110. (Zinc Oxide Primer). Assemble Wet.
3. Top Face Of First Coil To Be 1.0 To 1.5 Pitch Below This Surface. Break Off Tang At Notch.

For Holes Not Requiring Thread Inserts (Section B-B)

4. 0.190-24 NC-3B Minor Diameter. Depth 0.500 Inch Maximum, Drill Point 160° Minimum Included. Chamfer 90° ± 5° Included To 0.190 - 0.220 Inch Diameter. Minimum Full Thread Depth 0.407 Inch.

Reoperation Of Fan Exit Fairing

Figure 805

(4) Using PWA 30635 Wrench to hold brazed nut on brackets, unfasten clamps securing tubes to brackets on exhaust strut assembly. Remove tubes. Reinstall new tube assemblies as required.

11. Diffuser Case Repair

A. Crack Repair

(1) A crack may be repaired by welding with AMS 5776 filler metal. See Section 72-00, Inspection/Check for limits of acceptability. Stress-relieve after welding at 1000° - 1030°F (538° - 554°C) for two hours.

(2) A crack weld that redevelops cracks may be repaired by rewelding with AMS 5776 filler metal. Stress-relieve after welding at 1000° - 1030°F (538° - 554°C) for two hours. Otherwise repair must be made at overhaul.

NOTE: Use contact type pyrometer to gage temperature; stress-relieved area must overlap and extend three inches in all directions from crack.

B. Water Injection Bosses

CAUTION: USE SMALL WELD ROD IN THIS PROCEDURE TO REDUCE HEAT AND MINIMIZE DISTORTION.

(1) Weld and stress-relieve cracks around water injection bosses per Paragraph A., above.

12. Fireseal Crack Repair - Boeing Installation

A. Procedure - Circumferential Cracks (Six O'Clock Area), Lower Fireseal Assembly

See Figure 806.

(1) Stop drill end of cracks.

(2) Provide clearance cut in spacer and rivet spacer onto fireseal.

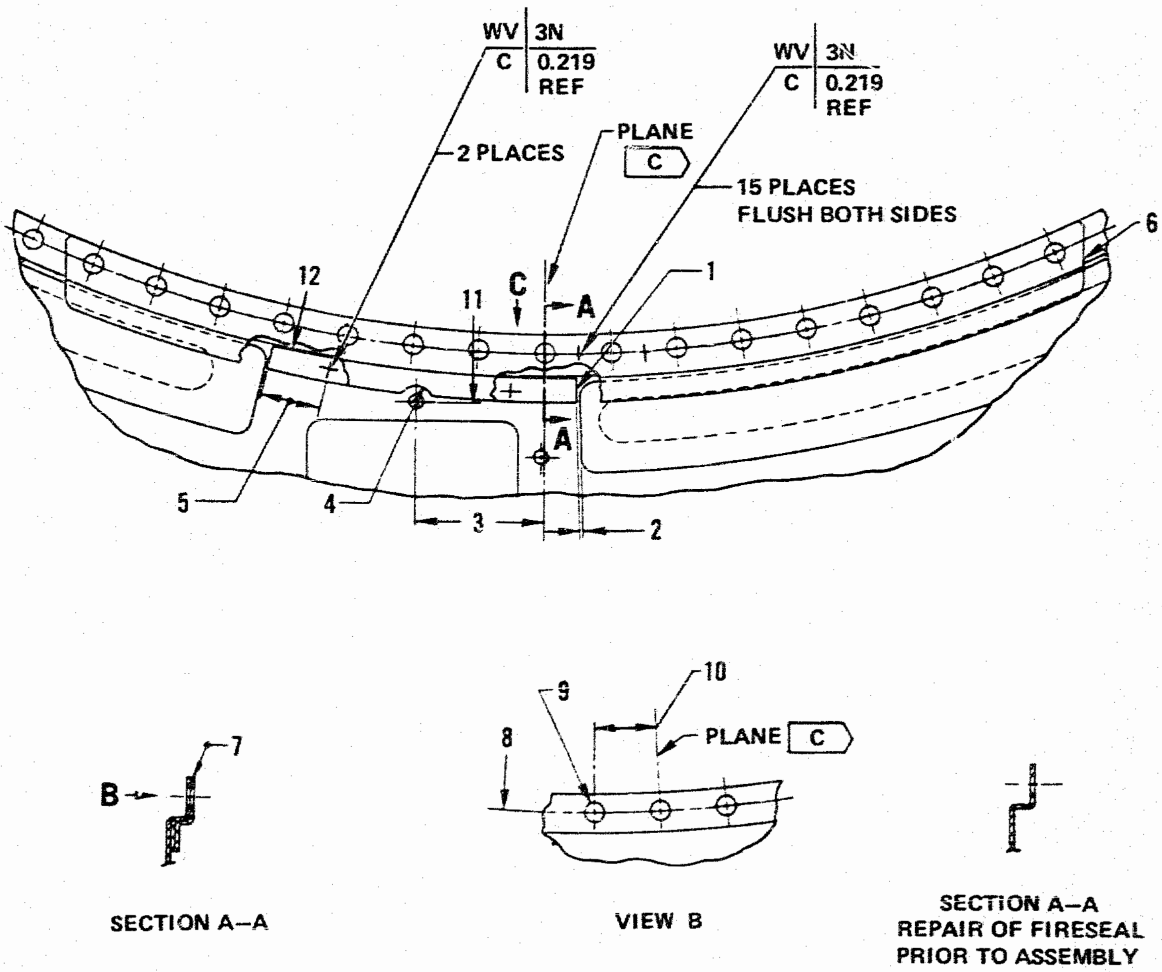
(3) Predrill boltholes in braze as shown in referenced figure.

(4) Install brace over face of fireseal and bolt on.

NOTE: The use of brace on fireseal necessitates longer bolts in holes encompassed by brace.

(5) At assembly, replace six bolts MS9035-12 with six bolts MS9035-13; eight bolts MS9035-13 with eight bolts MS9035-14; two bolts MS9035-14 with two bolts MS9035-15, in area of lower fireseal.

ENGINE - APPROVED REPAIR



1. Spacer PN 702096
2. 0.010 Inch Maximum. Two Places. Machine Spacer If Necessary.
3. 2.100 Inches
4. 0.250 - 0.281 Inch Radius, Located Within 0.005 Inch Radius Of True Position.
5. 1.000 Inch, Both Ends.
6. Brace, PN 702273
7. This ID Surface Of Brace, No. 6, Must Be Flush Or Below Adjacent ID Surface Of Fireseal.
8. 20.580 Inches Radius, Reference
9. 0.339 - 0.349 Inch Diameter Through Brace No. 6. 16 Holes Located From Holes In Fireseal.
10. 3° Reference
11. 21.430 Inches To Centerline
12. 21.110 - 21.150 Inches Radius

Fireseal Crack Repair - Boeing Installation

Figure 806

(6) At first convenient opportunity repaired part is to be reworked per Overhaul instructions.

13. Turbine Exhaust Case - Bolt-on Doubler

A. Doubler For Mount Rail Crack Repair (JT3D-1BG -1MC6BG -3BBG).

NOTE: This repair is for cases having cracks between engine mount holes and outer edge of mount rail. Only one rail can be reoperated. Bolt-on doubler can be used with or without existing tee plate, but any cracked cases which have bolt-on doublers added should be repaired at next scheduled overhaul.

(1) Method of reoperation:

(a) Scheme I (if cracks are on rear mount rail).

See Figure 807 (Sheet 1 and 2).

1 Remove brackets at thermocouple locations

2 Install bolt-on doubler, spacers, bolts and nuts at 45 degree locations.

3 Relocate thermocouple cables and add new brackets.

(b) Scheme II (if cracks are on front mount rail).

See Figure 808.

1 Install bolt-on doubler, spacers, bolts, and nuts at 45 degree locations.

(2) Assemble bolt-on doubler in place on rail and install one mounting bolt through doubler, case rails, and spacer.

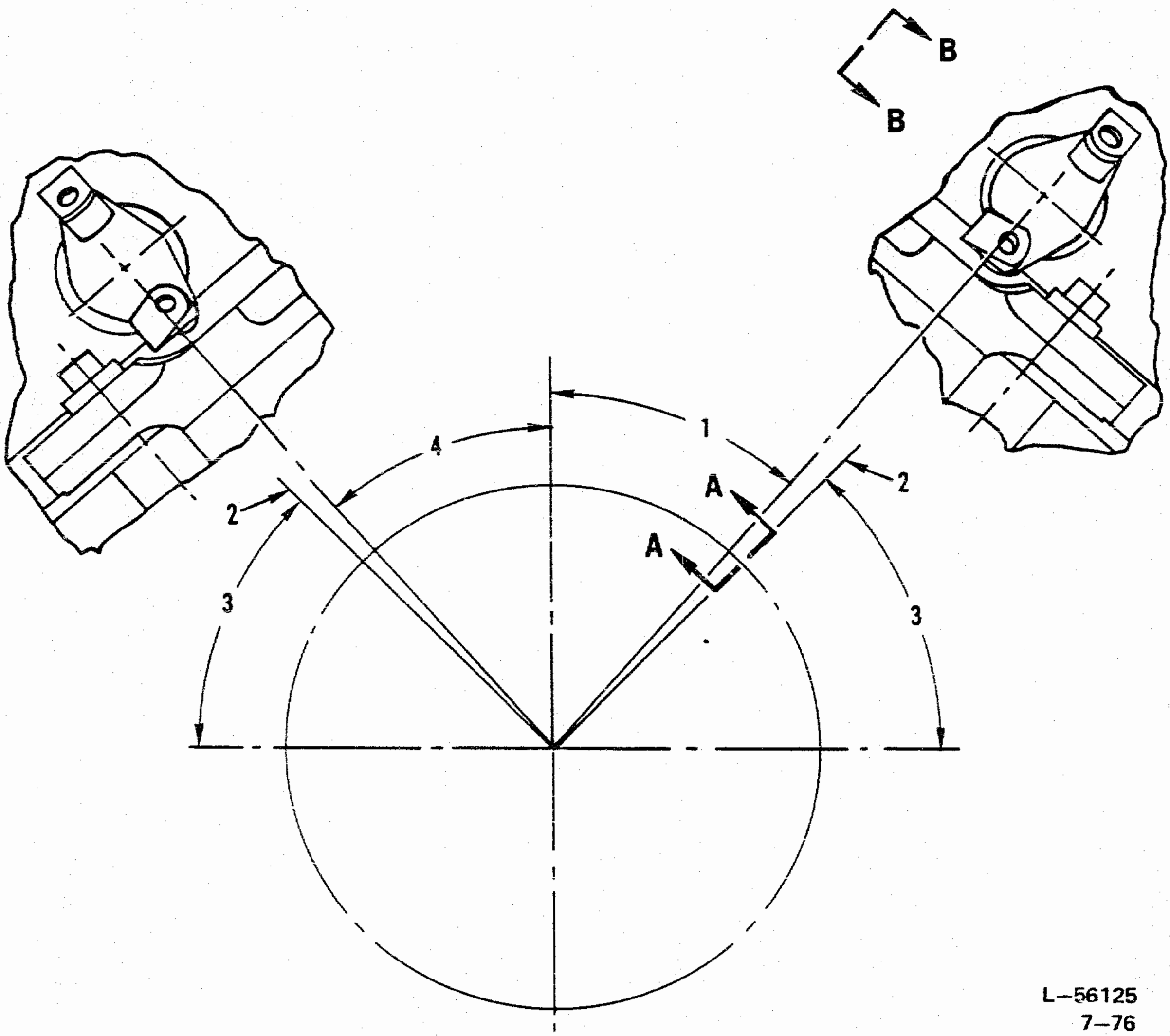
(a) Threaded end of bolt must not protrude past stack up more than 0.500 inch to insure tapered bolt head is not seated.

(3) Push down on unbolted doubler end until holes line up enough to install other bolt and spacer.

(4) Install doubler nuts and torque to standard torque for 0.500 - 20 thread size.

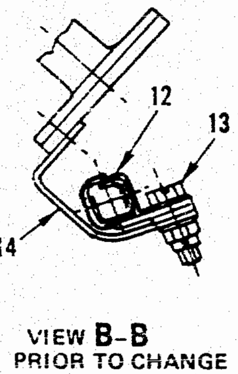
NOTE: If tapered head is not fully seated increase torque to 1500 inch-pounds maximum until head is seated and then back off torque to standard value.

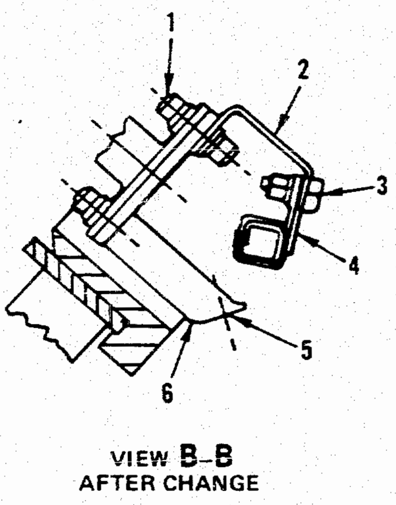
ENGINE - APPROVED REPAIR

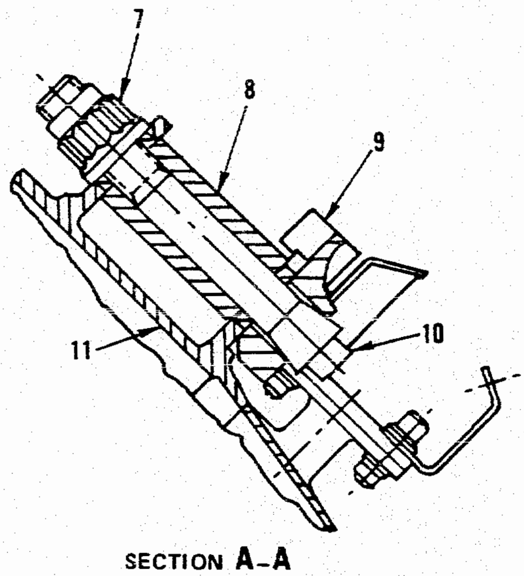


1. 41°
2. Bolt Location
3. 45°
4. 41° 30'

Turbine Exhaust Case Rear
Mount Rail (Scheme 1)
Figure 807 (Sheet 1)



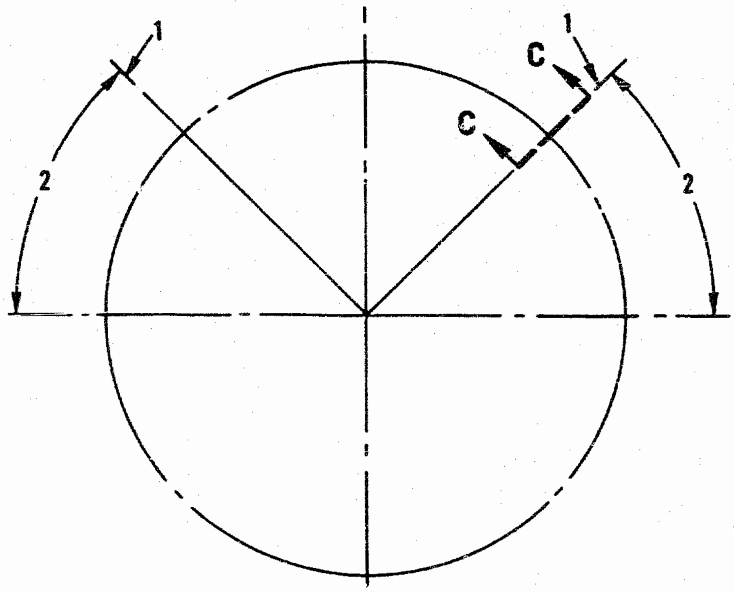


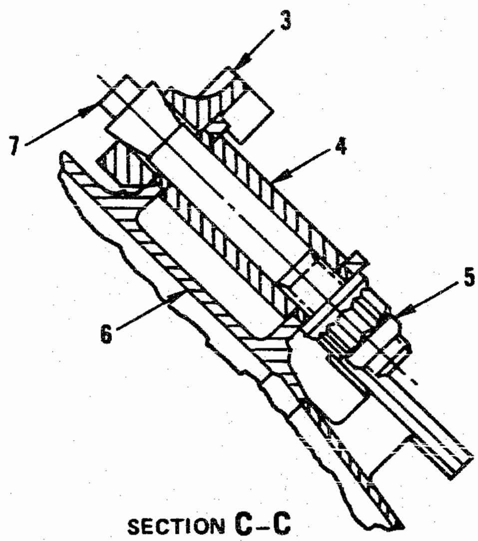


1. PN 315959 Nut And PN MS9034-11 Screw - Two Required
2. PN 760283 Bracket Two Required
3. PN 375094 Nut And PN MS9316-04 Screw Two Required
4. Thermocouple Cable Clamp.
5. Airframe Attachment Hole For Thrust Reverser Line Clamp.
6. PN 760281 Bracket Two Required
7. PN 754673 Nut Two Required
8. PN 754627 Spacer Two Required
9. PN 758648 Bolt-on Doubler
10. PN 758649 Bolts Two Required
11. Turbine Exhaust Case
12. Thermocouple Cable Clamp
13. Prior Screws, Spacer, Reuse Nuts
14. Prior Bracket

Turbine Exhaust Case Rear
Mount Rail (Scheme 1)
Figure 807 (Sheet 2)

ENGINE - APPROVED REPAIR





1. Bolt Location
2. 45°
3. PN 758648 Bolt-on Doubler
4. PN 754627 Spacers Two Required
5. PN 754673 Nuts Two Required
6. Turbine Exhaust Case
7. PN 758649 Bolts Two Required

Turbine Exhaust Case Front Mount
Rail (Scheme II)
Figure 808

ENGINE - APPROVED REPAIR

B. Doubler for Mount Rail Crack Repair (JT3D-1DS, -3DS, -3BDS, -3BDSLG)

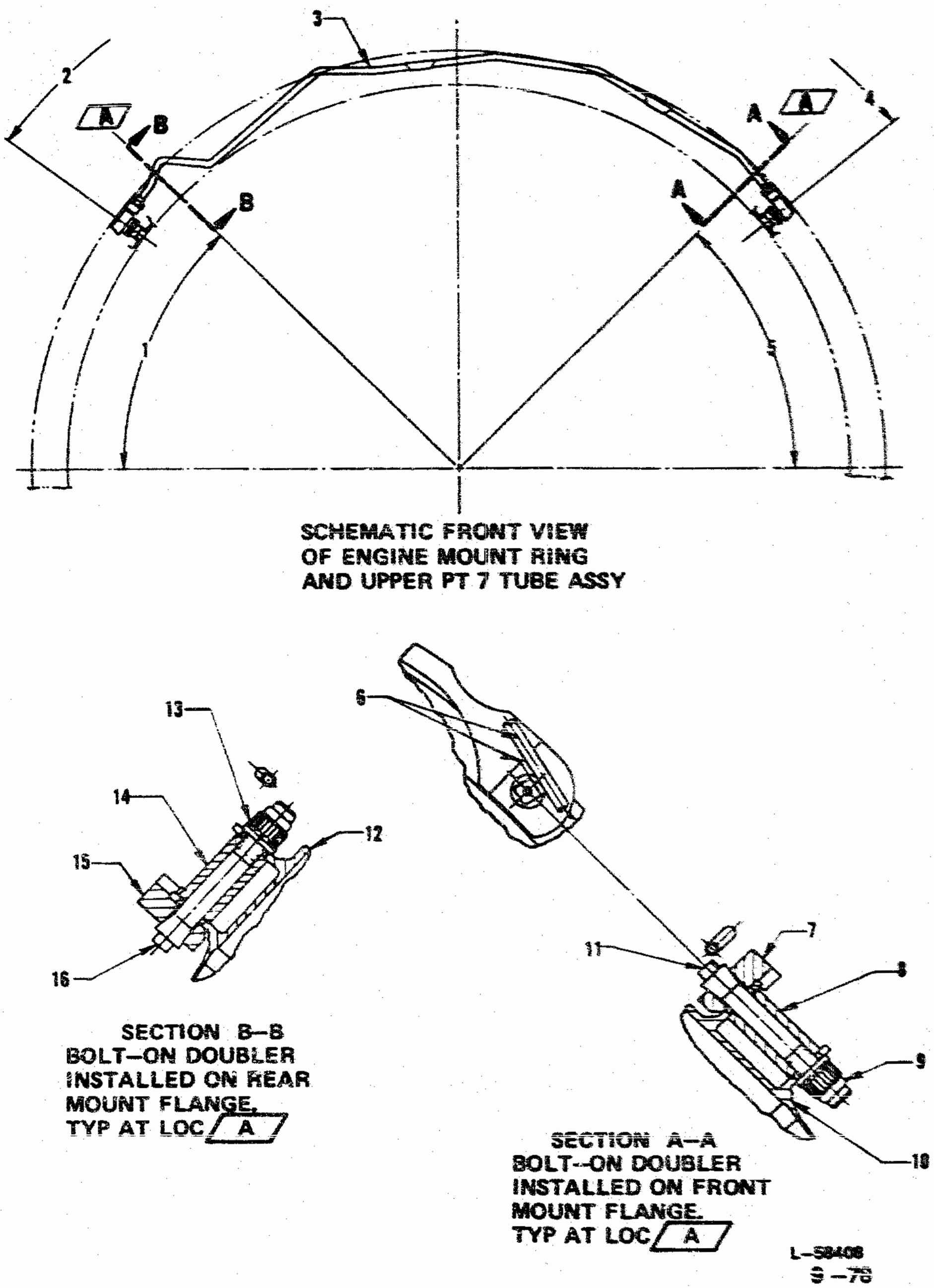
NOTE: This repair is for cases having cracks between engine mount holes and outer edge of flange on either front or rear rail flanges. Only one of either of rail flanges can be repaired by this procedure. Bolt-on doubler can be used with or without existing tee plate, but any cracked case which has bolt-on doublers added should be repaired at next scheduled overhaul.

(1) Cracks on rear mount flange
(a) Remove existing Pt7 manifold tube assembly.
(b) Install bolt-on doubler, spacers, bolts and nuts at locations shown in Figure 809 and as follows:
1 Assemble bolt-on doubler in place on flange and install one mounting bolt through bolt-on doubler, case flange, and spacer as shown. Threaded end of bolt must not protrude past stackup more than 0.500 inch to ensure tapered bolthead is not seated.
2 Push down on unbolted doubler end until holes line up enough to install other bolt.
3 Install both nuts and tighten to standard torque for 0.500 - 20 threaded size. If tapered head is not fully seated, increase torque to 1500 pound-inches maximum until head is seated and then back off torque to standard torque for 0.500 - 20 thread.
(c) Install new Pt7 manifold tube assembly (PN 767963).
(2) Cracks on front mount flange
(a) Remove existing Pt7 manifold tube assembly.
(b) Install bolt-on doubler, spacers, bolts, and nuts at location shown in Figure 809 and substep (1)(b).
(c) Install new Pt7 manifold tube assembly (PN 767963).

C. Bolt On Reinforcing Plates (Doublers) For Turbine Exhaust Cases Exhibiting Cracks In Rails.
(1) Bolt on reinforcing plates (doublers) are intended only for temporary repair of cracked turbine exhaust case rails which are within the following limits.
(2) Bolt on reinforcing plates (doublers) may be installed while engine is installed on the aircraft.
(3) Bolt on reinforcing plates (doublers) may be installed on either or both turbine exhaust case rails. Turbine exhaust case may be continued in use within the following crack limits and after application of bolt-on reinforcing plates 758648 or 767961.

Limits:
(a) Rail cracks extending outward from the engine mounting holes toward the OD of the turbine exhaust case rails.
(b) Cracks extending inward from the turbine exhaust case rail OD toward the engine centerline and terminating within the limits of Figure 810 (Zone G).

ENGINE - APPROVED REPAIR



Turbine Exhaust Case
Mount Rail Repair (Douglas)

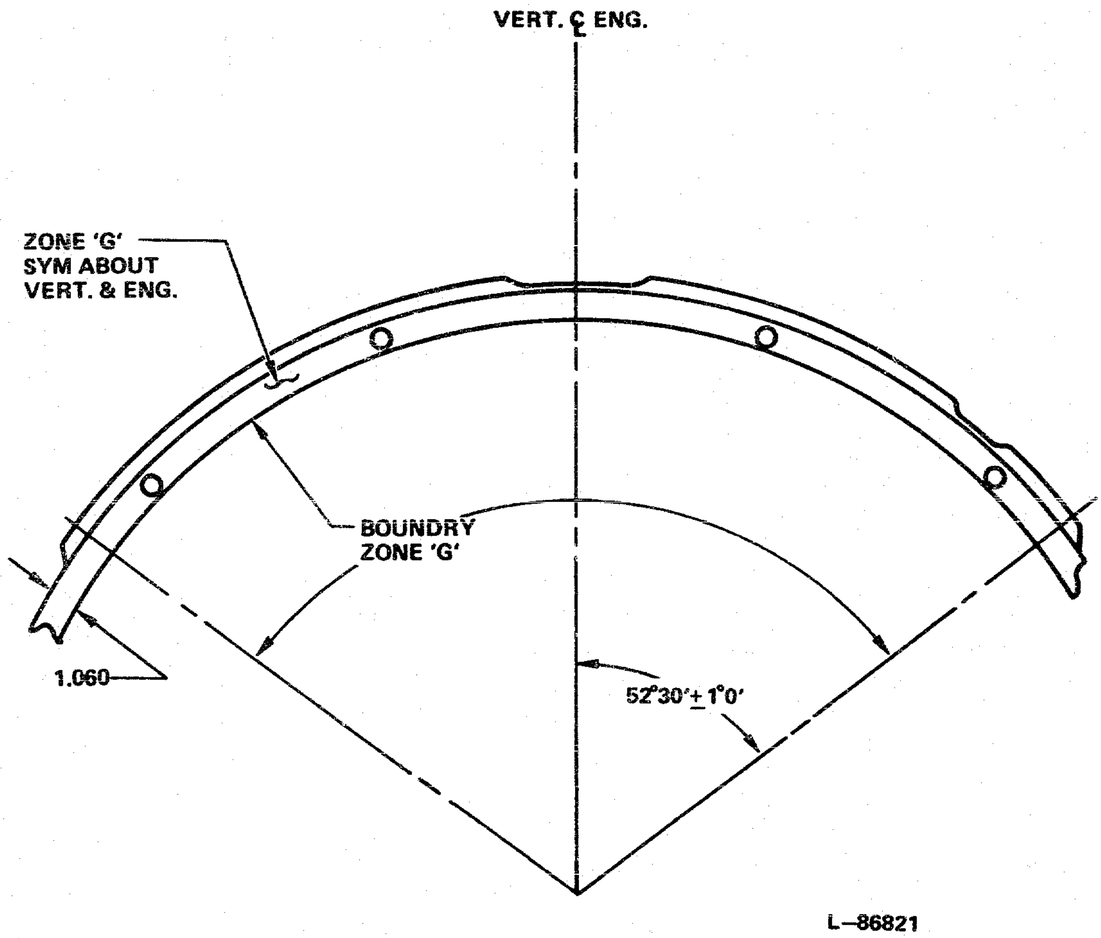
Figure 809

ENGINE - APPROVED REPAIR

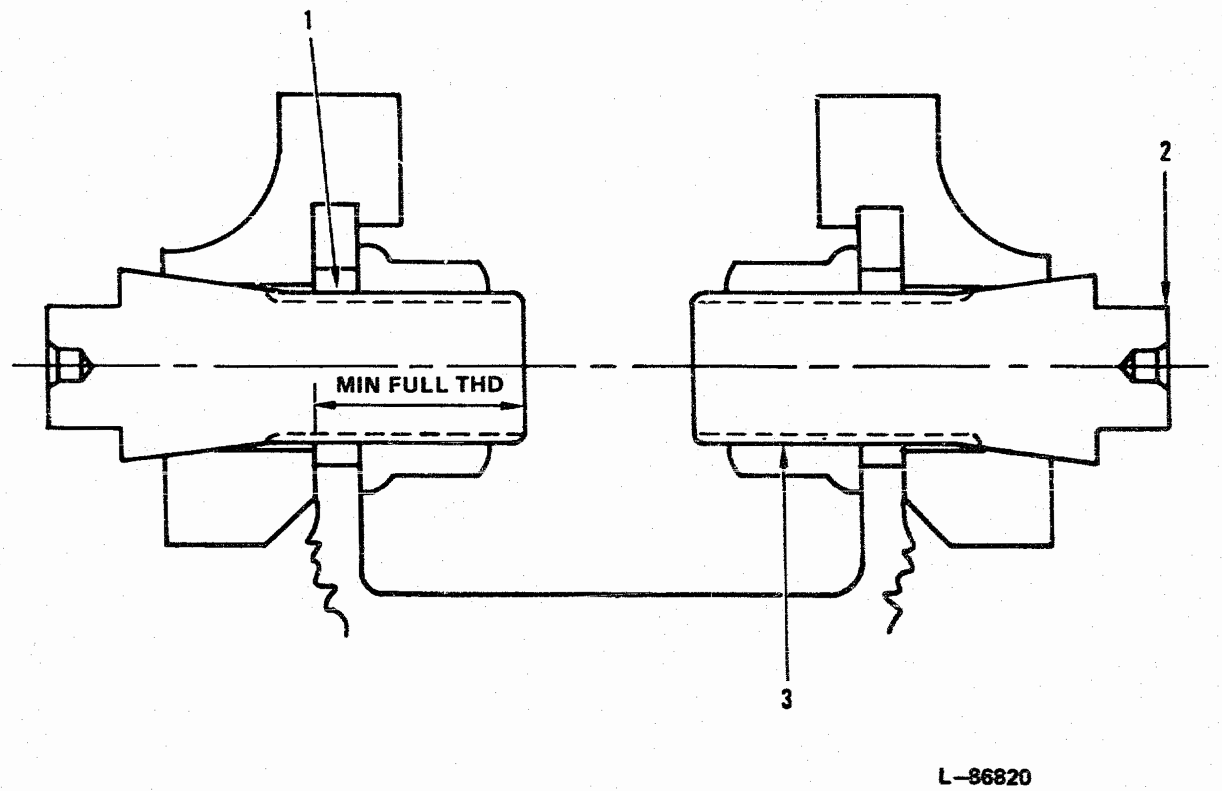
1. 45°
2. 53° Reference
3. PN 767963 Pt7 Manifold Tube Assembly
4. 51°
5. 45°
6. Install Bolt With This Flat Approximately Parallel With Axis Of Tube
7. PN 767961 Bolt-on Doubler
8. PN 754627 Spacer
9. PN 754673 Nut
10. Turbine Exhaust Case
11. PN 758649 Bolt
12. Turbine Exhaust Case
13. PN 754673 Nut
14. PN 754627 Spacer
15. PN 767961 Bolt-on Doubler
16. PN 758649 Bolt

Key To Figure 809

R D. Bolt On Reinforcing Plates (Doublers) <u>May</u> <u>Not</u> Be Used For Any Of The
R Following Conditions:
R (1) Turbine exhaust case rail with any crack from a ground handling hole
R located at 45 degrees on either side of the TDC of the case.
R (2) Cracks at mount holes extending inward and terminating beyond the limits
R of Figure 810 (Zone G).
R E. Reinforcing Plate (Doubler) Installation
R (1) Position one reinforcing plate (doubler) PN 758648 on either of the
R turbine exhaust case rails as shown in Figure 811.
R (2) Insert a bolt PN 790027 through one end of the reinforcing plate
R (doubler) and the turbine exhaust case rail and install a nut finger-
R tight only.
R (3) Shift the bolt until the nut face contacts the inner surface of the
R turbine exhaust case rail. Force the opposite end of the reinforcing
R plate (doubler) into alignment with the handling hole in the turbine
R exhaust case rail, and install a second bolt and nut also fingertight.
R (4) Tighten both nuts to a torque of 625 - 700 lb-in. and inspect the bolt
R heads. Both of the 15 degree tapered bolt heads must be fully seated
R in the reinforcing plate (doubler).
R
R <u>NOTE</u>: If necessary to fully seat the bolt heads either or both nuts
R may be further tightened to a torque of a maximum of 1000 lb-in.
R followed by an immediate reduction to a torque of 625 -
R 700 lb-in.



R Turbine Exhaust Case Rail
R Crack Limit Locations
R View Looking Forward
R Figure 810



R 1. 0.0015 - 0.0122 Inch, Reference Diameter
R 2. Same As PN 758649 Except For Overall Length And Thread Specification.
R 3. 0.625-18 UNJF-3A Thread Specification

R Turbine Exhaust Case
R Bolt On Reinforcing
R Plates Installation
R Figure 811

R ENGINE - APPROVED REPAIR

R (5) Position the second reinforcing plate (doubler) on the opposite turbine exhaust case rail and repeat the procedure outlined above.

R F. Inspection Of Turbine Exhaust Cases Repaired Using Reinforcing Plates (Doublers)

R (1) Frequent inspection is required after installation of bolt on reinforcing plates (doublers). The inspection schedule shall be the responsibility of each operator based upon rail crack propagation rates experienced in the class of service involved.

R (2) Turbine exhaust case may be continued in use only while rail cracks remain within the limits of Paragraph C., steps (3)(a) and (b).

14. Numerical Tool List

PWA 30634

LIST OF EFFECTIVE PAGES

Please insert the revised pages into this manual and delete obsolete pages in accordance with the following List of Effective Pages. Revised pages are indicated by the letter "R", added pages by the letter "A", and deleted pages by the letter "D". Superseded pages shall be removed and destroyed.

The List of Effective Pages records not only each page of subject revision but also each previously issued page which is still current. Blank pages and pages which are no longer current do not appear on this list. If there is any question about the currency of the recipient's copy, it is recommended that each page of the manual be checked off against this List of Effective Pages. Any page which does not check out with this list, either by number or by date, shall be discarded.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

FUEL SYSTEM - DESCRIPTION AND OPERATION

Fuel System Function

The principal function of the fuel system is to deliver fuel to the engine at such pressures and flow rates as are required to achieve the engine power output desired. A secondary function is the automatic compensations for the variations in altitude encountered in flight. Technical limitations in engine design impose a third function; that of limiting acceleration fuel flows so as to prevent surge and excessive engine pressures and temperatures. The final function of a fuel system is the establishment of a minimum fuel flow to prevent "lean die-out" of the flame of combustion during deceleration.

These four essential functions are accomplished by the fuel system largely through the intricate workings of its major component, the engine-driven fuel control. The fuel control acts as a kind of intermediary between the pilot and his engine. It translates his power lever signals to increase or decrease fuel flows, and it monitors certain flight variables of which the pilot may not be aware, therby relieving the pilot of the chore of continual power-setting adjustments.

Operation of the Fuel System

The operation of the fuel system employed in the engine and the functions of its various components may best be described by tracing the passage of fuel from the inlet connection of the fuel pump to its ultimate discharge through the fuel nozzles in the engine combustion chambers.

Fuel

The fuel for the engine shall conform to PWA 522 Specifications.

Fuel contamination may occur in shipment, during transfer from one container to another, or in the aircraft fuel system from scale, lint from packings and seals, and deterioration of fuel lines and hoses. Serious malfunction of the engine will occur, even to the extent of engine stoppage, as a result of contaminants in the fuel reaching the engine fuel system. It is important, that the mesh screen in the aircraft fuel system upstream of the engine fuel pump be inspected periodically for removal of all foreign particles.

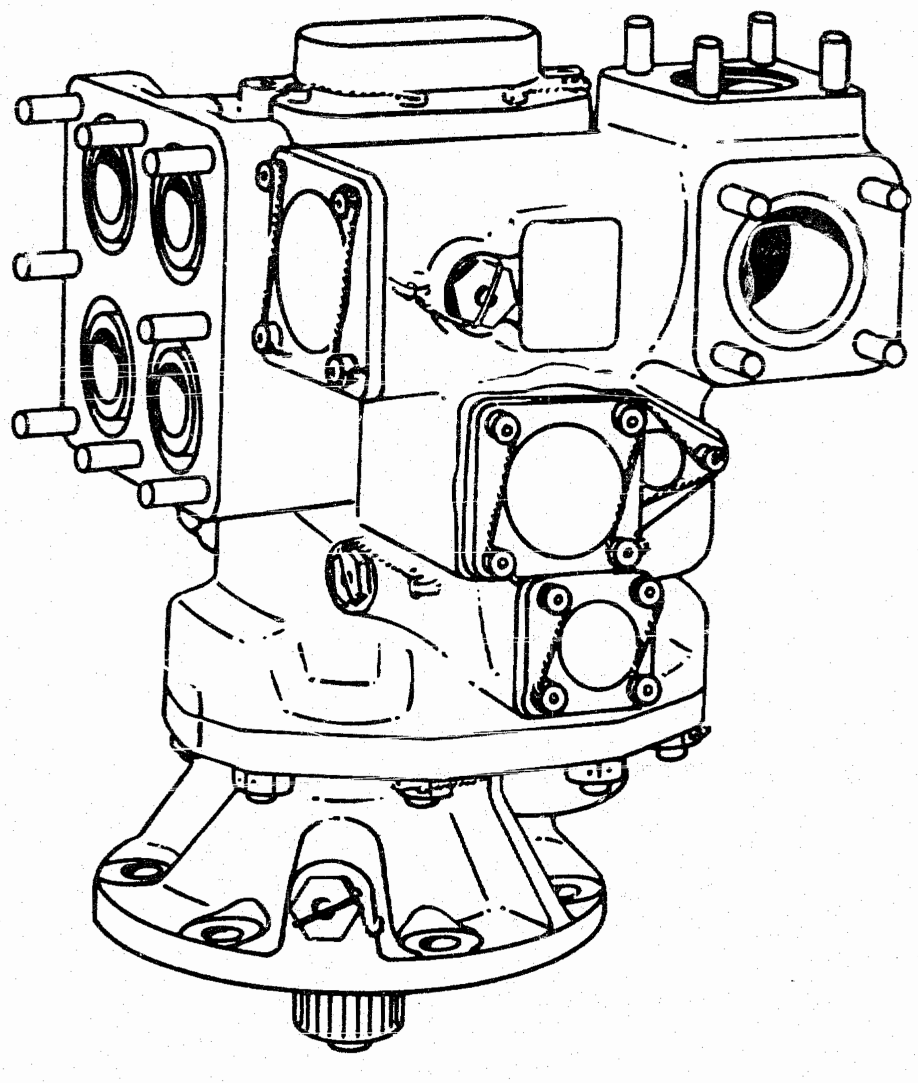
Fuel Tubes

Aircraft fuel tubing brings fuel to the main fuel pump inlet. If the PWA fuel de-icing system (optional equipment) is used, a large tube from the pump carries the fuel to the fuel de-icing fuel-heater buildup just aft of the pump. Another tube returns the fuel to the pump from the filter. If the fuel de-icing system is not installed, the mounting holes in the pump are blanked off. Two large tubes are mounted on the bottom between the fuel pump and the fuel control. The forward tube is the fuel return tube (high pressure) and the rearward tube is the fuel supply tube. The rearmost tube between the pump and the control is the bypass tube (low pressure). From the right side of the fuel control to the right side of the fuel pressurizing and dump valve, a large tube supplies fuel to the valve.

Fuel Pump

See Figure 1.

The first component to be considered in the engine fuel system is the fuel pump. The pump is a two stage, engine driven, bypass equipped unit which receives fuel from the aircraft fuel tank system and discharges it at predetermined pressures and quantities through a fuel de-icing system (optional equipment) to the fuel control. The two, positive displacement, gear-type, pumping stages operate in series; the boost stage discharging to the fuel de-icing system through a heater and filter which in turn discharges into the main stage and from there to the fuel control.



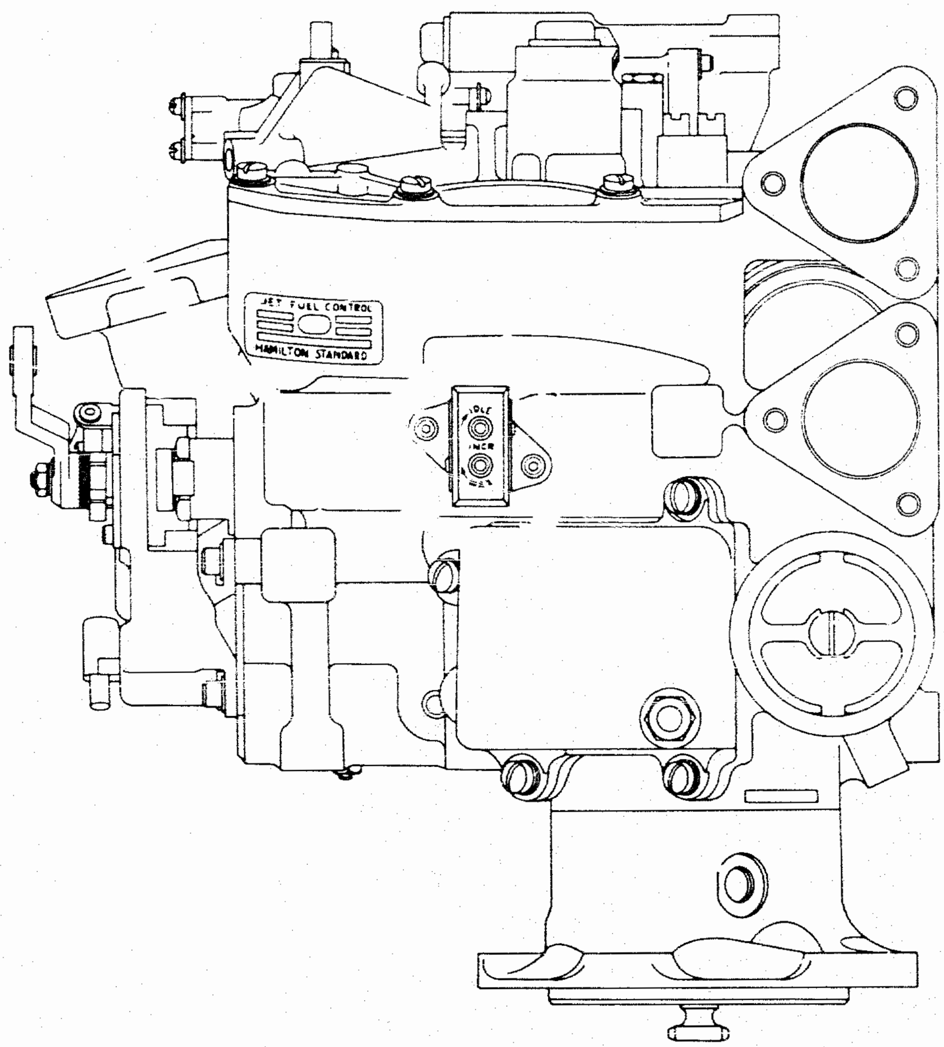
Fuel Pump

Figure 1

Fuel Control

See Figure 2.

The fuel control is a hydromechanical fuel metering unit designed to schedule fuel flow to control engine speed, thus governing thrust output. It provides the correct flow of fuel to the engine to establish and maintain the engine speed selected by the pilot. It accomplishes this by varying the fuel flow in response to changes in combustion chamber pressure, and in the difference between the desired speed and the actual engine speed. Fuel from the control is discharged into the fuel-oil cooler (optional equipment) and then to the fuel pressurizing and dump valve.



L-7384

Fuel Control

Figure 2

FUEL SYSTEM - DESCRIPTION AND OPERATION

Fuel-Oil Cooler (Optional Equipment)

Metered fuel from fuel control enters fuel-oil cooler. This unit has been previously discussed under lubrication system since its prime function is to help cool oil in conjunction with airframe supplied air-oil cooler. It consists of a cylindrical unit mounted in front lower right quadrant of diffuser case. Fuel flows through tubes in core of cooler and oil circulates within housing and around outside of tubes. Heat from oil is transferred to fuel via conduction. This unit is discussed further in Oil Chapter. See Chapter 79.

Fuel Pressurizing and Dump Valve

Discharge fuel from control via fuel-oil cooler passes into fuel pressurizing and dump valve. The purpose of this valve is to provide division of flow between primary and secondary nozzle orifices to ensure proper spray pattern for efficient fuel combustion. Also incorporated in fuel pressurizing and dump valve body is a fuel dump valve which drains primary fuel manifold at shutdown.

Fuel Manifold

See Figure 3.

Fuel from fuel pressurizing and dump valve enters engine fuel manifold which provides separate paths for primary and secondary fuel flow.

Fuel Nozzles

See Figures 4 and 5.

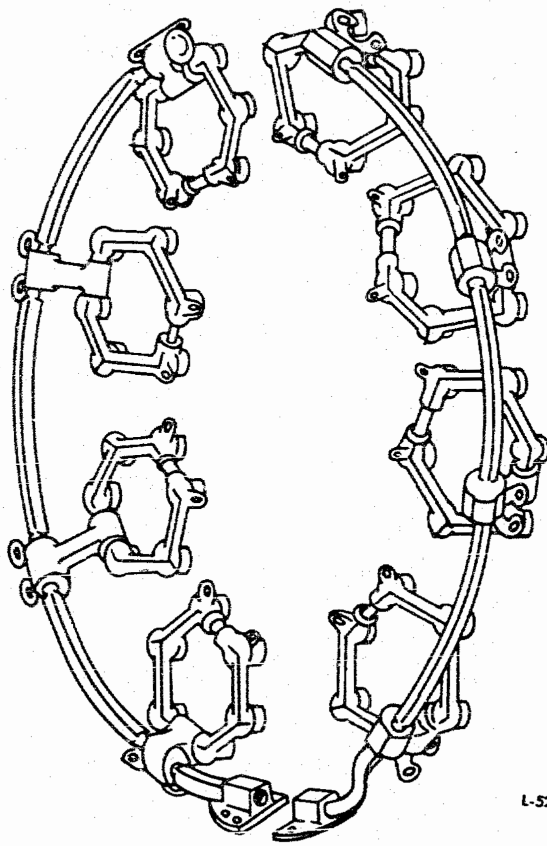
The forty-eight fuel nozzle assemblies are supported in fuel manifold and are arranged in eight clusters of six nozzles each. Each cluster projects into accommodating apertures in upstream end of each engine combustion chamber. Each nozzle incorporates two sets of metering slots and two sets of swirl chambers, in effect, constituting a nozzle within a nozzle.

Each nozzle is designed to discharge a predetermined amount of fuel when specified pressure drops are maintained across primary and secondary stages, acting both as an atomizing and metering device. The nozzle must deliver a uniform spray pattern free from streaks.

Drain Connections

Plugged drain connections are provided on fuel components as well as in combustion chamber case. The pressurizing and dump valve drain line, combustion chamber drain line, and fuel component drain lines are airframe installations.

FUEL SYSTEM - DESCRIPTION AND OPERATION



Fuel Manifold

Figure 3

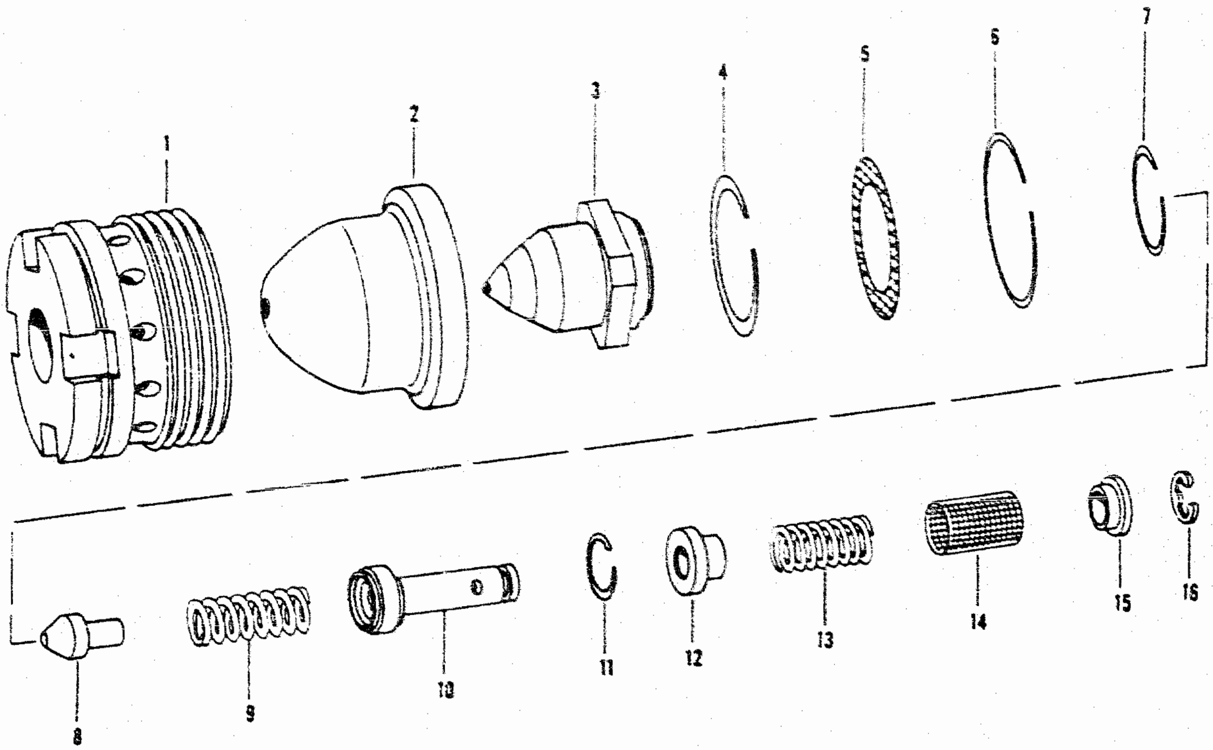
Fuel De-Icing System (Optional Equipment)

As has been discussed elsewhere, the fuel delivered to the engine must be free of all solid contaminants larger than that which will pass through a 200 mesh screen, and also must be practically free of solid contaminants of a smaller size. Serious fuel control malfunction will result if fuel containing a quantity of dissolved or free water is furnished to the fuel control system at temperatures which would cause ice crystals to enter the control or to form ice within the control. The fuel control can be protected by maintaining the temperature of the fuel entering the fuel system high enough to prevent formation of ice from free or dissolved water.

FUEL SYSTEM - DESCRIPTION AND OPERATION

The principal components of this system are an air-fuel heater and a fuel filter. The air-fuel heater uses 16th stage air as a source of heat. The filter protects fuel system from ice, and heater thaws filter when fuel flow is restricted by ice. The fuel filter is fitted with a pressure-drop warning switch. The heater has a pad to which an over-temperature warning bulb may be attached to alert operator when temperature of fuel going out of heater exceeds a predetermined limit. The heater is turned on and off by actuating an anti-icing shutoff valve located at inlet end of heater.

The system is designed to be used intermittently, and heat is turned on only as needed to thaw filter when it becomes iced.



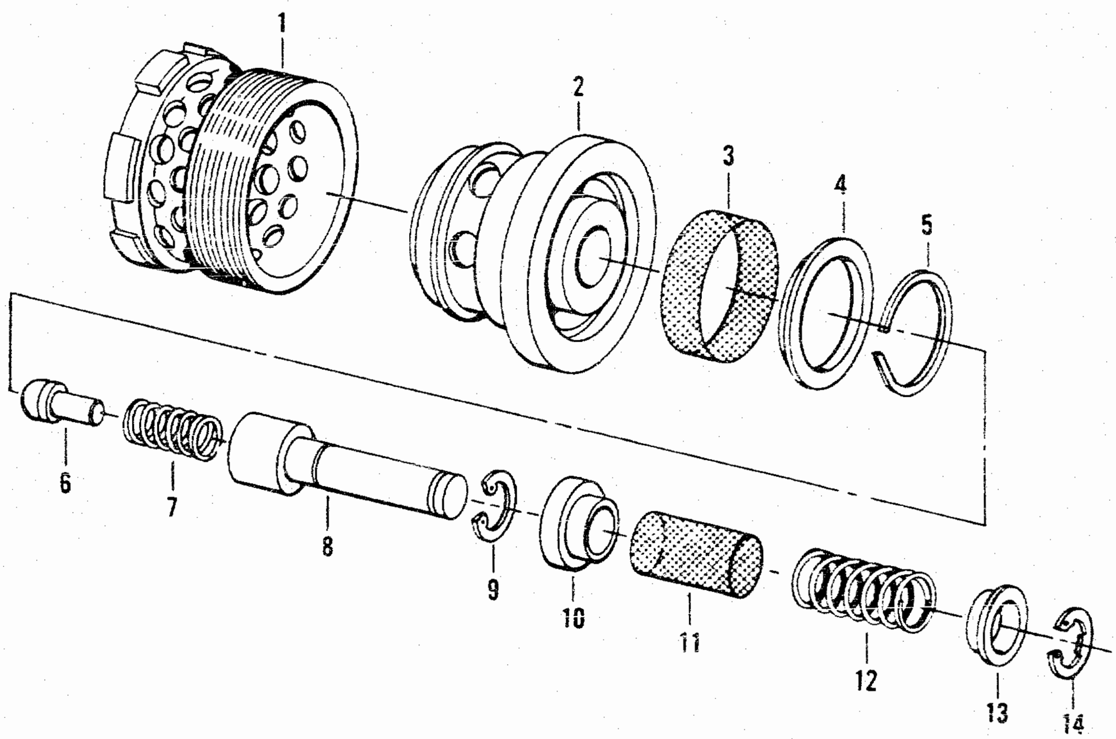
1. RETAINING NUT
2. NOZZLE BODY*
3. INSERT*
4. INSERT SNAPRING
5. SECONDARY STRAINER
6. SECONDARY STRAINER OUTER SNAPRING
7. SECONDARY STRAINER INNER SNAPRING
8. PRIMARY PLUG*
9. SPRING
10. SPRING SEAT
11. SPRING SEAT SNAPRING
12. LOWER PRIMARY STRAINER FERRULE
13. SPRING
14. PRIMARY STRAINER
15. UPPER PRIMARY STRAINER FERRULE
16. PRIMARY STRAINER SNAPRING

*MATCHED METERING SET DETAILS

L-5386

Non Aerated Fuel Nozzle
Figure 4

FUEL SYSTEM - DESCRIPTION AND OPERATION



1.	Retaining Nut	8.	Primary Strainer Body
2.	Fuel And Air Swirler	9.	Snapring - Primary Strainer Body
3.	Secondary Strainer	10.	Lower Primary Strainer Ferrule
4.	Secondary Strainer Ferrule	11.	Primary Strainer
5.	Secondary Strainer Snapring	12.	Spring
6.	Primary Insert	13.	Upper Primary Strainer Ferrule
7.	Spring	14.	Primary Strainer Snapring

Aerated Fuel Nozzle (PN 748822)
Figure 5

FUEL SYSTEM - DESCRIPTION AND OPERATION

Under all normal conditions, the heater is operated in the OFF position and there is no heat added to the fuel.

As ice collects on the surface of the filter, the filter pressure drop will slowly increase. When the filter pressure drop reaches a predetermined value, the pressure warning switch turns on a light in the cockpit, warning the flight crew that icing is being encountered. When this light goes on, the flight crew will turn on the heater for a short period, not to exceed one minute, to thaw the filter. When the filter has been thawed, its pressure drop will return to normal, the pressure drop warning light will go out, and the heater will be turned off. Ice, then, may start again to build up on the filter surface and the pressure drop will slowly increase until it reaches the predetermined value, at which the cycle will be repeated.

Fuel De-Icing Heater (Optional Equipment)

The fuel de-icing heater is an air-fuel heat exchanger attached to a filter assembly which is mounted on the side of the engine above and forward of the fuel pump. It consists of an air chamber surrounded by a fuel jacket. Sixteenth stage air is circulated through the air chamber. The heat from this air is transferred to the fuel circulating in the fuel jacket. The heater has a boss to which a temperature bulb may be attached.

Fuel De-Icing Filter Assembly (Optional Equipment)

The fuel de-icing filter assembly consists of a 40 micron filter element encased in a cylindrical housing. This housing is connected through a fuel line to the heater as described above. The filter assembly is fitted with a pressure drop warning switch, a bypass valve, and a water drain plug.

Water Injection System (Optional Equipment)

Due to the functional interrelationship of the water injection system with the engine fuel system, they should be discussed together. A detailed description of this system is covered in Chapter 82. It must be mentioned, however, that in conjunction with the fuel control, a switch is operated which passes electrical power for opening or closing the airframe supplied water injection shutoff valve. Also, a sensing line from the water injection control is attached to the fuel control for resetting the fuel controls maximum speed adjustment to a higher setting during water injection.

FUEL SYSTEM - TROUBLESHOOTING

1. General

A. Refer to Section 72-0, Engine - Troubleshooting.

FUEL SYSTEM - SERVICING

1. Draining the Combustion Chamber Pressure Sensing Tube Condensation Trap

A. Procedure

(1) Cut the lockwire and unscrew the condensation trap plug.

(2) Allow accumulated moisture to drain from the tube.

(3) Install a new seal, replace the plug, and tighten and lockwire the plug.

FUEL SYSTEM - REMOVAL/INSTALLATION

1. General

A. Tube and Hose Disconnection or Removal

(1) Tag each disconnected or removed hose and tube as to nomenclature and location.

(2) Tag or note location of all clips to ensure their reinstallation in correct position.

(3) Cap all disconnected or removed tubes and hoses.

(4) Cap any openings into engine caused by hose and tube removal.

(5) During removal of external fuel tubes, it may be desirable or necessary to remove tubes from another system in order to facilitate disassembly. Care shall be taken, however, to avoid scrambling parts from various systems.

2. Fuel System (Basic)

A. Fuel System Tubes - Removal

(1) Remove clip securing fuel pump-to-fuel control pressure tube to fuel control-to-fuel pump return tube. Remove clip securing fuel pump-to-fuel control fuel pressure tube to oil pressure tube.

(2) Loosen nuts securing fuel pump-to-fuel control fuel pressure tube to elbows on control and on pump. Remove fuel pump-to-fuel control fuel pressure tube.

(3) Remove clip securing fuel control-to-fuel pump by-pass tube to bracket on intermediate case mount ring. Remove clip securing fuel control-to-fuel pump by-pass tube to fuel control-to-fuel pump return tube.

(4) Loosen nuts securing fuel control-to-fuel pump by-pass tube to elbows on control and on pump. Remove fuel control-to-fuel pump by-pass tube.

(5) Loosen nuts securing fuel control-to-fuel pump return tube to elbows on control and on pump. Remove tube.

(6) Remove clip securing condensation trap-to-fuel pressurizing and dump valve air sensing tube to fuel control-to-fuel pressurizing and dump valve fuel sensing tube.

NOTE: On engines incorporating SB 3721, fuel control-to-fuel pressurizing and dump valve fuel sensing tube has been removed.

FUEL SYSTEM - REMOVAL/INSTALLATION

(7) Loosen the nuts securing the condensation trap-to-fuel pressurizing and dump valve air sensing tube to the elbow on the fuel pressurizing and dump valve and the connection on the condensation trap. Remove the condensation trap-to-fuel pressurizing and dump valve air sensing tube.

(8) Remove the clip securing the fuel control-to-condensation trap air sensing tube to the fuel control-to-fuel pressurizing and dump valve fuel sensing tube.

(9) Loosen the nuts securing the fuel control-to-condensation trap air sensing tube to the connection on the condensation trap and the reducer on the fuel control. Remove the fuel control-to-condensation trap air sensing tube.

(10) Remove the bolts securing the condensation trap and the bracket to the gearbox assembly. Remove the condensation trap.

(11) Loosen the nuts securing the fuel control-to-fuel pressurizing and dump valve fuel sensing tube at the elbows on the fuel control and on the fuel pressurizing and dump valve. Remove the tube.

(12) For the JT3D-1 Douglas JT3D-3 Douglas and JT3D-3B Douglas, remove the clips securing the fuel control-to-fuel pressurizing and dump valve fuel supply tube to the brackets at the front and rear flanges of diffuser case.

(13) For the JT3D-1 Douglas JT3D-3 Douglas and JT3D-3B Douglas loosen the nuts securing the fuel control-to-fuel pressurizing and dump valve fuel supply tube to the control and to the fuel pressurizing and dump valve. Remove the tube.

B. Fuel System Tubes - Installation

(1) For JT3D-1 Douglas, D-3 Douglas, and D-3B Douglas, install nut on plain end of fuel control-to-fuel pressurizing and dump valve fuel supply tube threaded end out. Install ferrule on plain end and after coating new packings with engine oil, install one on each end of tube together with retainer. Position tube to elbow on control and to elbow on fuel pressurizing and dump valve. Secure tube to elbows with nuts. Lockwire tube nuts.

(2) For JT3D-1 Douglas, D-3 Douglas, and D-3B Douglas, position clips on fuel control-to-fuel pressurizing and dump valve fuel supply tube to brackets at front and rear flanges of diffuser case. Secure clips with screws and locknuts. Torque screws.

FUEL SYSTEM - REMOVAL/INSTALLATION

(3) Position fuel control-to-fuel pressurizing and dump valve fuel sensing tube to elbows on fuel control and on fuel pressurizing and dump valve. Secure tube to elbows with nuts. Tighten nuts to recommended torque. Lockwire nuts.

NOTE: On engines incorporating SB 3721, fuel control-to-fuel pressurizing and dump valve fuel sensing tube has been removed.

(4) Place condensation trap and bracket on right side of gearbox assembly. Secure trap and bracket with bolts to gearbox assembly. Torque bolts. Lockwire bolts.

(5) Position fuel control-to-condensation trap air sensing tube to connection on trap and reducer on fuel control. Secure tube with nuts and tighten nuts to recommended torque. Lockwire nut on fuel control end of tube.

(6) Position clip securing fuel control-to-condensation trap air sensing tube to fuel control-to-fuel pressurizing and dump valve fuel sensing tube at location noted at disassembly. Secure clip with screw and nut. Tighten screw to recommended torque.

(7) Position condensation trap-to-fuel pressurizing and dump valve air sensing tube to trap and to fuel pressurizing and dump valve. Secure tube with nuts and tighten nuts to recommended torque. Lockwire nut at fuel pressurizing and dump valve end of tube; then lockwire two remaining tube nuts at condensation trap.

(8) Position clip securing condensation trap-to-fuel pressurizing and dump valve air sensing tube to fuel control-to-fuel pressurizing and dump valve fuel sensing tube at location noted at disassembly. Torque screw.

(9) Using new seal wet with engine oil, position fuel pump return tube inlet adapter on its pad on fuel pump. Tighten bolts to recommended torque and lockwire. Install new backup ring, and seal on fuel control to fuel pump return tube elbow. Install elbow into fuel control boss, and at the same time keep the nut turning until seal contacts the boss. While holding the nut stationary, turn elbow in until it contacts check valve. Position elbow by turning out not more than one turn.

(10) Coat new seals with engine oil and install one in each of fuel control-to-fuel pump return tube; then install retainer in both ends. Position tube to elbows on control and on pump; then secure it with tube nuts. Tighten tube nuts to recommended torque. Lockwire nuts.

(11) Torque fuel pump to fuel control return tube elbow nut and lockwire.

(12) Coat new seals with engine oil and install one in each end of fuel control-to-fuel pump bypass tube; then install retainer in both ends. Position tube to elbows on control and on pump; then secure it with tube nuts. Torque tube nuts and lockwire.

FUEL SYSTEM - REMOVAL/INSTALLATION

(13) Install clip securing fuel control-to-fuel pump bypass tube to bracket on intermediate case mount ring and install clip securing fuel control-to-fuel bypass tube to fuel control-to-fuel pump return tube in location noted at disassembly. Secure the clips with the screws and nuts. Torque screw.

(14) Coat new seals with engine oil and install one in each end of fuel pump-to-fuel control fuel pressure tube; then install retainer in both ends. Position tube to elbows on control and on pump; then secure it with tube nuts. Torque and lockwire.

(15) Install clip securing fuel pump-to-fuel control fuel pressure tube to fuel control-to-fuel pump return tube in location noted at disassembly. Secure clip with screw and nut. Torque screw.

3. Removal/Installation of Fuel De-Icing Leads, Hose and Tubes (Optional Equipment)

A. Removal

(1) Remove the screw and nut that secure the clips between the anti-icing air supply tube and the fuel de-icing air supply hose assembly. Remove the clips.

(2) Remove the bolts securing the fuel de-icing hose assembly rear adapter to the pad on the diffuser case lower left quadrant; then remove the bolts and nuts securing the hose assembly front adapter to the air shut-off valve located on the top of the heater assembly. Remove the hose assembly.

(3) Loosen the nuts securing the heater-to-filter tube assembly to the elbows on the heater and on the filter; then remove the tube.

(4) Loosen the nuts securing the filter-to-pump tube assembly to the elbows on the fuel filter and on the fuel pump; then remove the tube.

(5) Remove the nuts securing the pump-to-heater tube assembly adapter to the fuel pump adapter. Remove the bracket and clip; then loosen the tube nut securing the tube to the elbow on the heater. Remove the tube.

B. Installation

(1) Coat new packing and seal with fuel; then install the packing on the adapter end of the pump-to-heater tube assembly and the seal on the other end. Install a retainer on the seal. Position the tube to the studded boss on the fuel pump adapter and to the lower rear elbow on the heater. Install the nuts on the adapter and secure the tube nut to the elbow. Tighten the nuts and tube nuts to the recommended torque.

(2) Coat new seals with fuel and install them in each end of the filter-to-pump tube. Install retainers in each end and position the tube to the rear facing elbow on the fuel pump adapter and on the filter. Tighten the tube nuts to the recommended torque.

(3) Coat new seals with fuel and install them in each end of the heater-to-filter tube. Install retainers in each end and position the tube to the forward facing elbow on the filter and the topmost elbow on the heater. Tighten the tube nuts to the recommended torque.

(4) Using new gaskets, position the air supply hose assembly to the pad in the left quadrant of the diffuser case and the air shut-off valve located at the top of the heater assembly. Secure the hose assembly to the diffuser pad with the bolts and to the air shut-off valve with the bolts and nuts. Tighten the bolts and the bolts and nuts to the recommended torque.

4. Removal/Installation of Fuel Coolant Oil Cooler Tubes (Optional Equipment)

A. Fuel Oil Cooler Fuel Tubes - Removal (Optional, JT3D-1 Boeing and JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6, and JT3D-1-MC7)

NOTE: Tag or note location of clips to ensure reinstallation in proper location.

(1) Remove the clip assembly securing the cooler-to-control fuel tube to the cooler-to-dump valve tube; then remove the clip securing the cooler-to-dump valve fuel tube to the bracket at the 5 o'clock location on the diffuser case rear flange.

(2) Remove the nuts securing the cooler-to-dump valve fuel tube flange to the boss on the top of the fuel-oil cooler; then unfasten the nut at the elbow on the fuel pressurizing and dump valve. Remove the cooler-to-dump valve fuel tube.

(3) Remove the tube nuts securing the control-to-cooler fuel tube to the elbows on the top of the control and on top of the fuel-oil cooler. Remove the tube.

B. Fuel-Oil Cooler Fuel Tubes - Removal (JT3D-3B-DL)

NOTE: Note or tag location of clips to ensure reinstallation in proper location.

(1) Unfasten nut on upper end of fuel flowmeter tube and remove bolts from flanged end of tube at pad on fuel control. Remove fuel flowmeter tube, seal and retainer from engine.

(2) Remove bolt and nut from clip securing fuel flowmeter adapter to center of diffuser case front flange and then remove bolts at lower flanged end of adapter to remove fuel flowmeter adapter and fuel tube connector from engine.

FUEL SYSTEM - REMOVAL/INSTALLATION

(3) Unfasten nut on oil cooler inlet fuel tube and remove straight adapter, packing and retainer.

(4) Remove bolts in flange end of oil cooler inlet fuel tube on front side of cooler and remove tube and packing.

(5) Remove screw and nut from clips securing the two oil cooler tubes together. Remove screw and nut from clip securing oil cooler tube to bracket at center of intermediate case. Unfasten nut securing oil cooler tube to front coupling on bracket support attached to front case flange at approximately seven o'clock position and then remove nuts securing flanged end of tube to top of cooler. Remove oil cooler tube from engine.

(6) Remove screws and nuts from clips on oil cooler tube. Unfasten nut securing forward end of tube to rear coupling on bracket support attached to front case flange and remove nuts from flanged end of tube on right side of gearbox. Remove tube and packing.

(7) Remove bolts securing the two couplings to bracket support on front case flange and remove coupling.

(8) Remove screws and nuts from clips on oil cooler fuel outlet tube. Unfasten tube nut at lower end of tube and then remove nuts securing flanged end of tube to lower rear pad of cooler. Remove oil cooler fuel outlet tube, seal, packing and retainer from engine.

(9) Remove nuts securing oil cooler fuel shut-off valve to rear side of pressurizing and dump valve and remove valve and packing from engine.

C. Fuel-Oil Cooler Fuel Tubes Installation (Optional, JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7)

(1) Using new packing, assemble oil cooler fuel line elbow to top of control with bolt and washer in inner hole of flange of elbow; bolt and flat airframe bracket in outside forward end of flange; and an angle airframe bracket and bolt in outside rear end of flange. Torque bolts.

(2) Lubricate two seals and install one in each end of control-to-cooler fuel tube; then install retainer in both ends. Position tube to elbows on top of cooler (topmost) and on top of control. Torque tube nuts.

(3) Lubricate new seal and install it in dump valve end of oil cooler-to-fuel pressurizing dump valve tube; then install retainer. In flanged end of tube, install lubricated seal and position flanged end of tube to fuel-oil cooler top studded boss and secure it with nuts. Fasten dump valve end to fuel pressurizing and dump valve elbow with tube nut. Torque tube nut and flange nuts. Lockwire tube nut.

FUEL SYSTEM - REMOVAL/INSTALLATION

(4) Position clip assembly between cooler-to-dump valve and cooler-to-control tubes (at the location noted at disassembly). Secure clip assembly with screw and nut. Tighten nut to recommended torque. Secure cooler to dump valve tube with clip to bracket at five o'clock location on diffuser case rear flange. Torque nut.

(5) Install oil tank drain plug with new packing in bottom of oil tank. Torque plug 200 to 250 pound-inches.

(6) For configuration incorporating oil tank with low level gage boss in lower left of tank, install cover with new packing on boss and secure with bolts and nuts. Torque nuts.

D. Fuel Oil Cooler Fuel Tubes - Installation (JT3D-3B-DL Engines)

(1) Install packing on elbow end of fuel shut-off valve; then install valve over studs of pad on rear side of pressurizing and dump valve. Secure with washers and nuts.

(2) Install packing on flanged end of oil cooler outlet fuel tube and packing and retainer on nut end. Secure tube to pad at rear bottom outlet pad cooler with nuts. Secure other end of tube to fuel shut-off valve connection. Torque tube nut.

(3) Install tube couplings (2) in the bracket support attached to front case flange at approximate seven o'clock position. Flange of couplings to be positioned toward outside of support. Secure with bolts.

(4) Install packing on flanged end of oil cooler tube and packing and retainer on nut end. Install tube over studs of pad at top of cooler. Secure with nuts. Secure other end of tube to front coupling installed in step (3). Tighten tube nut to torque of 200 to 220 pound inches.

(5) Install packing on flanged end of oil cooler inlet tube and packing and retainer on nut end of tube. Secure flanged end of tube on four stud pad on right side of gearbox assembly with nuts. Secure other end of tube to rear coupling installed in step (3). Tighten tube nut to torque of 200 to 220 pound inches.

(6) Install packing on flanged end of oil cooler inlet fuel tube and packing and retainer on other end. Secure flanged end of tube to three stud pad on front side of cooler. Tighten nuts to recommended torque.

(7) Install straight adapter into tube installed in step (6). Install packing on adapter.

FUEL SYSTEM - REMOVAL/INSTALLATION

(8) Install clip at top of fuel flowmeter adapter. Install packing and retainer in adapter. Install boss connection nut onto fuel tube connector; then install connector onto flowmeter adapter by threading it onto connector. Secure with boss connection nut.

(9) Install adapter and connector assembled in step (8) onto the straight adapter installed in step (7). Secure with bolts and lockwire.

(10) Install seal and retainer on nut end of fuel flowmeter tube and packing on flanged end. Secure nut end of tube to connector and flanged end of tube to pad on fuel control. Secure with bolts and lockwire.

FUEL SYSTEM - INSPECTION/CHECK

1. Periodic Inspection

A. General

(1) These inspection procedures are a normal function of operating organizations. They consist of required inspections and minor adjustments necessary on the engine. The nature and conditions of engine operation determine the time interval between required inspections. For this reason, the intervals described in the periodic inspection charts are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because the extensive mass air flow tends to draw foreign objects into the engine. Thoroughly clean the entire compartment with a vacuum cleaner after completion of any work. Keep the compartment free of dirt, oil and grease, and remove all unused parts, such as nuts, washers and pieces of lockwire. Immediately cover all apertures resulting from the disconnection of tubing or parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect the exterior of the engine without dismantling to ensure that all connections are tight.

FUEL SYSTEM - INSPECTION/CHECK

B. Periodic Inspection Chart

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
Fuel	a. Presence of water at fuel tank only.	X	X	X
Engine Fuel Pump	a. Check for leakage.	X	X	X
	b. Security of quick disconnect clamp.		X	X
	c. Filter screen for foreign matter or damaged screen.	X	X	X
	NOTE: The filter screen must be checked frequently in new aircraft, and after fuel tank rework.			
Fuel De-Icing Filter	a. Presence of water.	X	X	X
	b. Filter element for foreign matter.	X	X	X
Hydromechanical Fuel Control	a. Security of quick disconnect clamp.	X	X	X
	b. Electrical leads and connections for wear, damage, and security.	X	X	X
	c. Evidence of leakage.	X	X	X
	d. Security of mechanical linkage.	X	X	X
	e. Obstruction of fuel overboard drain line.	X	X	X
	f. Fuel control inlet filter (coarse filter) for foreign matter or damaged screen.	X	X	X
	NOTE: On new airplanes check and replace with clean screen after each flight until no contamination is found.			

FUEL SYSTEM - INSPECTION/CHECK

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
	g. Servo fuel filter (fine screen portion of inlet filter) for foreign matter or damaged screen.	X	X	X
	NOTE: See note under f above. Frequency of inspection is contingent on degree of contamination of main (coarse) filter.			
	h. Accumulation of water in burner pressure bellows cavity.		X	X
Pressurizing and Dump Valve	a. Security of accessible lines and fittings.	X	X	X
	b. Security of mounting.		X	X
	c. Inspect screen.		X	X
Fuel Manifold and Nozzles	a. Dissimilarity of carbon buildup. Lack of carbon buildup may indicate a clogged nozzle.			X
	NOTE: A check for plugged nozzles or spray discrepancy must be performed. See 73-5-1, Inspection/Check.			
	b. Broken or missing tablocks.			X
	c. Localized damage due to heat.			X

C. Specific Periodic Inspection

(1) Exhaust Gas Temperature Spread Check

(a) Periodically evaluate the physical condition and flow characteristics of the fuel nozzles.

NOTE: The integrity of the testing equipment must also be checked.

FUEL SYSTEM - CLEANING/PAINTING

1. Cleaning Flexible Tubes

A. Procedure

(1) Remove all caps.

(2) Clean the tubes by spraying with petroleum solvent, using a brush, if necessary.

(3) Drain the tubes thoroughly and remove all excess fluid with compressed air making absolutely certain no foreign material remains in the tubes.

(4) Reinstall caps.

2. Cleaning Steel Tubes

A. Procedure

(1) Steel tubes may be cleaned as outlined above for flexible tubes.

(2) If harder to clean soils are encountered, clean as follows:

(a) Remove excessive oil.

(b) Immerse in an appropriate cold carbon remover for ten to thirty minutes or more as required.

(c) Rinse thoroughly in hot water.

(d) If necessary, to remove any remaining cleaning compound, pressure wash with petroleum solvent, then remove all excess fluid with compressed air.

(e) Make certain no foreign material or cleaning compound remains in the tubes.

(f) Reinstall caps.

FUEL PUMP - DESCRIPTION AND OPERATION

General

The two-stage fuel pump is an engine driven, by-pass equipped pump used to supply fuel at predetermined pressures and quantities to the fuel control. It is driven by the accessory gear train of the engine at 0.344 of rear compressor speed. The pump is mounted on the left front flange of the gearbox assembly, under the intermediate case.

It incorporates an inlet fuel filter with a self-relieving valve, two positive displacement gear type pumping elements, one relief valve, one check valve, one pressure regulating valve, and one drive shaft incorporating a rotary seal.

Operation

The two positive displacement gear type pumping elements operate in series to supply fuel in required quantities and pressures to the engine fuel control. These two pumping elements are arranged so that the boost stage acts as a pressure boost pump for the main stage, which in turn supplies the fuel to the engine fuel control. Control of internal fuel pressures as well as main stage discharge pressure is maintained by a group of three valves.

NOTE: Capitalized fuel port titles found in the following text are equivalent to similar port identifications molded in the pump castings.

Power to drive the pump is supplied by the engine through a mounting pad which accommodates the pump main drive shaft spline. Exterior plumbing is utilized to bring fuel to (1) inlet port, FUEL IN: (2) fuel from the engine fuel control at body pressure to the by-pass return port, BY PS RET: (3) engine fuel control main by-pass fuel to the main stage return port, PRIM RET: (4) fuel from the boost stage discharge port, SEC OUT (if incorporated, through the engine fuel de-icer) to the boost stage return port, SEC RET: and (5) fuel from the main stage discharge port, PRIM OUT to the engine fuel control.

Under normal operating conditions, fuel flows through the pump from the FUEL IN port and the inlet fuel filter element and self-relieving valve to the boost stage, out the SEC OUT port through the engine fuel de-icer (if incorporated) to the SEC RET port, to the main stage and out of the PRIM OUT port to the engine fuel control. Fuel not required by the engine is returned to the pump through the PRIM RET and BY PS RET ports.

Main Stage Pressure Relief Valve "A": This pressure relief valve controls the maximum value of the pump discharge pressure and is set to open when main stage discharge fuel pressure reaches approximately 1050 psi. When the valve is open main stage discharge fuel.flow is by-passed internally to the inlet side of the main stage pumping element. Normally the "A" valve is closed during operation.

FUEL PUMP - DESCRIPTION AND OPERATION

Main Stage Inlet Check Valve "B": If the boost element fails, this valve will open, providing a fuel supply to the main element. The "B" valve is normally closed during operation.

Boost Stage Pressure Regulating Valve "D": This relief valve controls the pressure of the fuel delivered to the engine fuel de-icer system (if incorporated), and therefore, the pressure of fuel delivered to the main stage inlet. The valve is set to open at between 45 and 65 psi above inlet pressure. When the valve is open, fuel is recirculated internally to the pump inlet.

Description

An aluminum alloy body houses the pump, the three valves, and the filter. A flange adapter, bolted between the pump body and the gearbox housing drive pad, carries the main drive shaft and its seal diaphragm assembly. A splined drive is used. The main pump gears are at the drive end of the body. The boost pump gears are driven by a splined hub that fits into a main pump gear. The filter screen is not a spring-loaded by-pass type. "O" rings are used for sealing where necessary. The main stage pressure relief valve setting is shop adjustable with shims. The remaining valves are not adjustable.

FUEL PUMP - REMOVAL/INSTALLATION

1. General

A. Disconnect or remove all necessary tubes to permit fuel pump removal. See Chapter 73-0, REMOVAL/INSTALLATION for tube removal and installation instructions.

NOTE: Refer to Chapter 72-0, Engine-Adjustment/Test for procedures to be followed subsequent to removal/installation of the fuel pump or the fuel pump filter.

2. Removal/Installation of the Fuel Pump

A. Removal

(1) Remove the clips securing the fuel pump-to-fuel control pressure tube. Loosen the nuts securing the tube to the elbows on the control and on the pump and remove the tube.

(2) Remove the clips securing the fuel pump-to-fuel control by-pass tube. Loosen the nuts securing the tube to the elbows on the control and on the pump and remove the tube.

(3) Remove the clip securing the fuel control-to-fuel pump return tube. Loosen the nuts securing the tube to the elbows on the control and on the pump and remove the tube.

(4) From engines on which the optional equipment fuel de-icing heater is installed, remove the clip securing the fuel pump-to-fuel heater inlet tube. Loosen the nut securing the tube to the heater elbow, remove the three locknuts securing the tube to the pump and remove the tube.

(5) From engines on which the optional equipment fuel de-icing filter is installed, remove the clips securing the fuel de-icing filter-to-fuel pump tube. Loosen the nuts securing the tube to the elbows on the filter and on the pump and remove the tube.

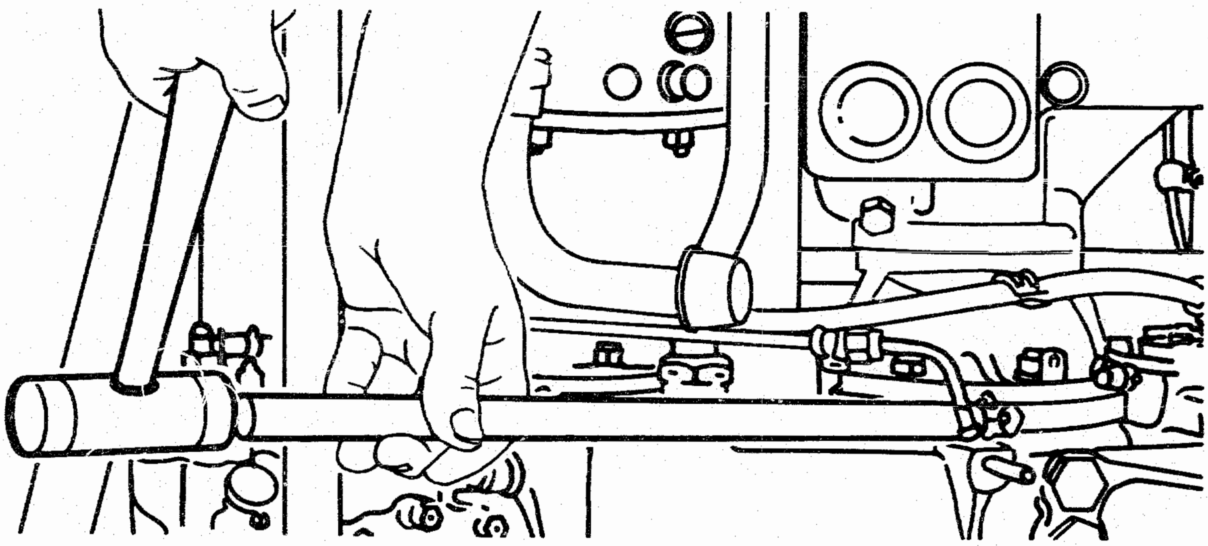
(6) Back-off the nut of the bolt attached to the accessory drive pad bracket; then loosen the bolt to disengage the mating part of the accessory drive pad nut assembly. See Figure 401.

(7) Supporting the fuel pump, turn the pump and accessory drive pad nut assembly counterclockwise (front view) to disengage from the mating adapter attached to the accessory and component drives gearbox. Then carefully withdraw the fuel pump to disengage the mating splines.

CAUTION: DO NOT LET THE WEIGHT OF THE FUEL PUMP BE TRANSMITTED TO THE PUMP SPLINES DURING REMOVAL.

(8) Remove the packing from the OD of the accessory drive pad.

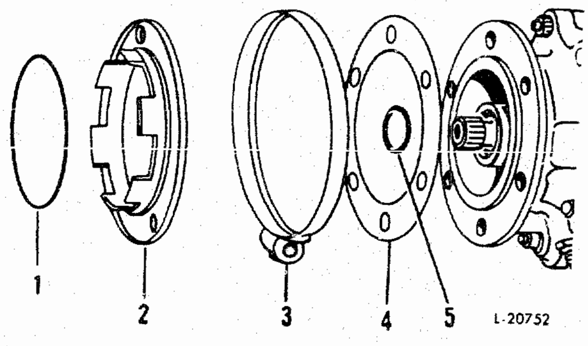
FUEL PUMP - REMOVAL INSTALLATION



L-5371

Loosening Mounting Adapter
Figure 401

(9) Remove the locknuts and washers securing the accessory drive pad nut assembly and the accessory drive pad to the flange of the fuel pump; then remove the bolts, accessory pad, accessory pad nut assembly, and the gasket from the fuel pump mounting flange. Remove packing from fuel pump drive gearshaft. See Figure 402.



1. Accessory Pad Packing
2. Accessory Pad
3. Accessory Pad Nut Assembly
4. Flange Gasket
5. Packing

Fuel Pump Mounting Arrangement
Figure 402

FUEL PUMP - REMOVAL/INSTALLATION

B. Installation

(1) Position the fuel pump on the bench with the mounting flange toward the operator.

(2) On engines having fuel pump drive splines lubricated by circulating engine oil (see SB 483), install new packing (5) on fuel pump driveshaft. See Figure 402.

(3) Position gasket (4), accessory pad nut assembly (3) and accessory drive pad (2) on fuel pump mounting flange. Secure with bolts, washers, and locknuts, positioning locknuts to fuel pump side.

(4) Place a new packing (1) on flange of accessory drive pad.

CAUTION: PACKING MUST GO OUTSIDE FINGERS OF PAD.

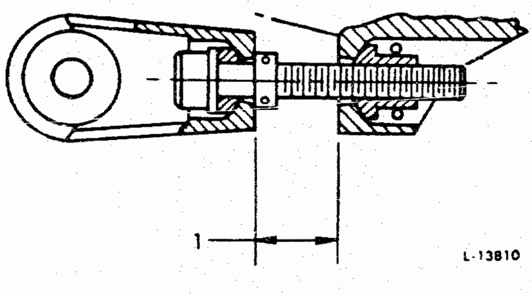
(5) Coat the fuel pump shaft mating splines sparingly with Plastilube No. 3 Compound.

CAUTION: THE FUEL PUMP DRIVE SPLINES ON SOME ENGINES ARE LUBRICATED BY ENGINE OIL WHICH CIRCULATES THROUGH OIL FEED HOLES DRILLED IN THE ACCESSORY DRIVE SHAFTGEAR. ON ENGINES THUS EQUIPPED, USE ONLY ENGINE OIL TO LUBRICATE THE PUMP AND SHAFTGEAR MATING SPLINES. DO NOT USE PLASTILUBE NO. 3 OR SIMILAR LUBRICANTS WHICH MIGHT PLUG THE OIL FEED HOLES.

(6) Install the fuel pump on the accessory and component drives gearbox assembly.

(7) Secure the pump by tightening the accessory pad nut assembly to engage the threads of the adapter. Lock the nut assembly by engaging the detail nut with the bolt of the accessory drive nut bracket. Tighten the bolt to the recommended torque and lockwire.

(8) Check for thread wear accessory drive pad nut bracket bolt by measuring distance between lug and attaching bracket. See Figure 403. A minimum distance of 0.625 inch, Index No. 1 is acceptable. A measurement of less than this limit is cause for rejection.



Bracket Bolt Wear Limit

Figure 403

FUEL PUMP - REMOVAL/INSTALLATION

(9) Check clearance between inner end of accessory drive pad nut assembly and fuel pump mounting pad of accessory drive gearbox assembly.

NOTE: When properly installed, clearance between inner end of accessory drive pad nut assembly and fuel pump mounting pad on accessory gearbox assembly shall be 0.029 to 0.052 inch and shall not vary more than 0.010 inch when checked at each 90 degree location.

(10) Install clips in locations noted at removal on fuel control-to-fuel pump return tube. Coat new seals with engine oil and install one in each end of tube. Install retainer in both ends, position tube to elbows on control and on pump, and secure tube with tube nuts. Tighten tube nuts to recommended torque and lockwire; then secure clips with screws and nuts. Tighten screws to recommended torque.

(11) Install clip in locations noted at removal on fuel control-to-fuel pump by-pass tube. Coat new seals with engine oil and install one in each end of tube. Install retainer in both ends, position tube to elbows on control and on pump, and secure tube with tube nuts. Tighten tube nuts to recommended torque and lockwire; then secure clip with screw and nut. Tighten screw to recommended torque.

(12) For Douglas LD engines, inspect connector, PN 226109 (AMS 4120 Aluminum), for thread size of 1.3125 - 12NS. Inspect threads over 0.0481 inch diameter wire pins. Reject any connector measuring 1.320 inch diameter or less. See Figure 404. It is permissible to use adapter, PN 590004 (AMS 5645 SST), in place of connector, PN 226109.

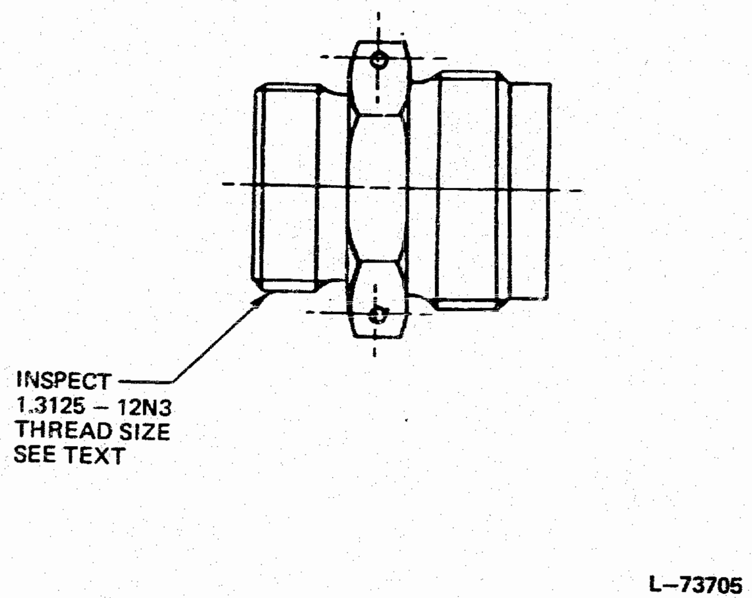
NOTE: For engines incorporating heli coil repair per SB 5321, also incorporate packing, PN MS9967-217, used with adapter, PN 590004, in place of packing, PN MS9387-16, used with connector, PN 226109.

CAUTION: WHEN INSTALLING PRESSURE TUBE, HOLD TUBE CONNECTOR SECURELY TO PREVENT OVER-TORQUE.

(13) Install connector or adapter into open port in fuel pump tube connector assembly. Tighten to a torque of 525 - 625 pound-inches.

(14) Coat new seals with engine oil and install one in each end of fuel pump-to-fuel control fuel pressure tube; then install retainer in both ends. Position tube to fitting on control and on pump; then secure with tube nuts. Tighten tube nuts to recommended torque and lockwire. Install clips in the location noted at removal, securing tube, and secure with screws and nuts. Tighten screws to recommended torque.

FUEL PUMP - REMOVAL/INSTALLATION



Inspection Requirements For PN 226109
Tube Connector
Figure 404

FUEL PUMP - REMOVAL/INSTALLATION

(15) On engines which incorporate optional equipment fuel de-icing heater, coat new seals with engine oil and install appropriate seal in each end of fuel pump-to-fuel heater inlet tube; then install retainer on heater end of tube. Position tube to heater elbow and pump adapter. Secure tube nut to heater elbow. Secure three locknuts to pump adapter. Tighten nuts to recommended torque and lockwire tube nut. Install clip in location noted at removal and secure with screw and nut. Tighten screw to recommended torque.

(16) On engines which incorporate optional equipment fuel de-icing filter, coat new seals with engine oil and install one in each end of fuel de-icing filter-to-fuel pump tube. Install retainer in both ends, position tube to elbows on control and on pump, and secure tube with tube nuts. Tighten tube nuts to recommended torque and lockwire. Install clips and secure with screws and nuts. Tighten screws to recommended torque.

3. Removal/Installation of the Fuel Pump Strainer Assembly

See Figure 405.

A. Removal

(1) Remove cover attaching bolts and washers and lift strainer assembly out of housing.

B. Installation

(1) Place new rubber preformed packing, coated with petrolatum, PMC 9609, or equivalent, on strainer body and install strainer body in fuel pump housing.

(2) Secure with bolts, and washers; torque bolts 20 to 30 pound-inches and lockwire.

4. Disassembly/Assembly of the Fuel Pump Strainer Assembly

See Figure 405.

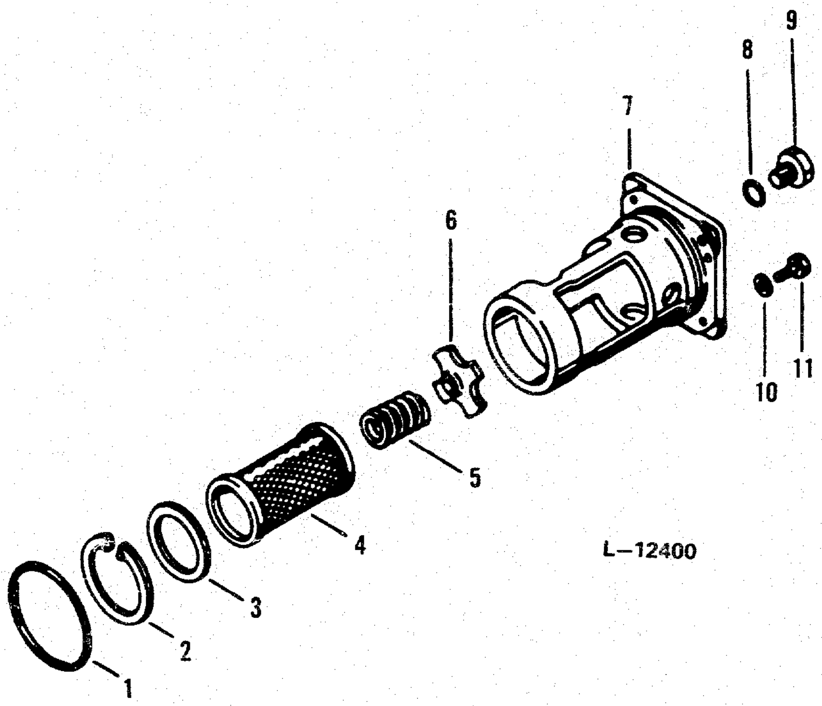
A. Disassembly

(1) Remove and discard snapring.

(2) Remove washers, fuel strainer element, spring and washer on the end.

NOTE: Do not remove helical coil inserts from fuel strainer body unless inspection indicates replacement is necessary.

FUEL PUMP - REMOVAL/INSTALLATION



1. "O" Ring Packing
2. Snapring
3. Washer
4. Fuel Strainer Element
5. Spring
6. Washer
7. Fuel Strainer Body
8. "O" Ring Packing
9. Plug
10. Flat Washer
11. Screw

Fuel Pump Strainer
Figure 405

FUEL PUMP - REMOVAL/INSTALLATION

(3) Remove plug and preformed packing from end of fuel strainer body. Remove preformed packing which seals fuel strainer body to pump housing.

NOTE: The preformed packing which seals fuel strainer body to fuel pump housing may make it extremely difficult to remove fuel strainer assembly from housing assembly. Use cover bolts as jacks to remove strainer assembly by screwing them into helical coil inserts. Screw bolts in evenly so as not to misalign assembly in housing.

B. Assembly

(1) Insert washer, spring, fuel strainer and thrust washer into strainer body.

(2) Lock in place with new snapring.

(3) Place preformed packing on plug and screw into body.

FUEL PUMP - CLEANING/PAINTING

1. Fuel Pump Filter

A. Procedure

(1) Rinse the filter in degreaser fluid or cleaning solvent; then dry with an air jet.

(2) Clean lint-clogged screens as follows:

(a) Insert the screen in a saturated solution of 1 liter of concentrated sulfuric acid (commercial grade) and 20 grams of sodium dichromate (technical grade) for a period of one minute. It may be necessary to heat the solution to 150°F (66°C) in order to dissolve the crystals.

(b) Remove the acid solution from the screen by rinsing thoroughly in clean water and drying with compressed air.

(c) Repeat steps (1) and (2) if any lint remains.

WARNING: AT CONCLUSION OF THE CLEANING PROCEDURE, DESTROY OR PROPERLY STORE THE PREPARED CLEANING SOLUTION.

FUEL CONTROL (WET) - DESCRIPTION AND OPERATION

1. General

The JFC-25 series fuel controls are designed to control the engine in either forward or reverse thrust operation under all operating conditions. Two control levers are provided; one controls the engine during forward or reverse operation and the other effects engine shutdown and starting by closing and opening a fuel shutoff valve. These controls have provisions for the use of water injection.

The fuel control accurately governs the engine steady state selected speed, acceleration, deceleration, maximum burner pressure, thrust reversal and provides a number of auxiliary signals. The speed governing system is of the proportional or droop type.

The fuel control may be considered as consisting of a metering and a computing section. The metering sections alters the fuel supplied to the fuel control by the engine-driven fuel pump to provide the engine thrust output demanded by the pilot but subject to engine operating limitations as sensed and scheduled by the control computing section. The computing section senses and combines various engine operational parameters to control the output of the metering section of the fuel control during all regimes of engine and aircraft operation.

2. Metering System

High pressure fuel is supplied to the control inlet from the engine driven pump. This fuel initially encounters the filtration system which consists of a coarse filter and a fine filter. The coarse filter protects the metering section against damage by fuel contaminants. This filter will by-pass when clogged to permit continued operation with unfiltered fuel. The fine filter protects the computing section against damage by fuel contaminants. This filter is self-cleaning through the metering system.

The fuel next encounters the pressure regulating valve. This valve is designed to maintain a constant pressure differential across the throttle valve. All high pressure fuel in excess of that required to maintain this pressure differential is bypassed to pump interstage pressure by the pressure regulating valve. The valve is servo controlled, whereby the actual pressure drop is compared to a selected pressure drop and any error is hydraulically compensated. The error resets the pressure regulating valve spring on this valve so that sufficient high pressure fuel is bypassed to maintain the selected pressure drop. The high pressure fuel, as altered by the pressure regulating valve, then passes through the metering valve. This valve consists of a contoured plunger which is positioned by the computing section of the control within a sharp-edged orifice. By virtue of the constant pressure drop maintained across the valve, the fuel flow is proportional to the position of the plunger. An adjustable stop is provided to limit the motion of the plunger in the decrease fuel direction to permit selection of the proper minimum fuel flow.

FUEL CONTROL (WET) - DESCRIPTION AND OPERATION

The final component to act upon the metered flow prior to its entry into the fuel manifold is the minimum pressure and shut-off valve. This valve is designed to shut off the flow of metered fuel to the engine when the pilot moves his shut-off lever to the "off" position. This generates a high pressure signal by means of the throttle operated pilot valve, which acts on the spring side of the shut-off valve, forcing it down against a seat, thus shutting off the flow of fuel to the engine. When the shut-off lever is moved into the "on" position, the high pressure signal is replaced by pump interstage pressure and when metered fuel pressure has increased sufficiently to overcome the spring force, the valve opens and fuel flow to the engine is initiated. Thereafter, the valve will provide a maximum operating pressure within the fuel control, ensuring that adequate pressure is always available for operation of the servos and valves at no less than minimum flow conditions.

3. Computing System

The computing system positions the throttle valve to control the steady state engine speed, acceleration, and deceleration. This is accomplished by using the ratio W_f/P_{t4} (the ratio of metered fuel flow to engine burner pressure) as a control parameter.

The positioning of the throttle valve by means of the W_f/P_{t4} parameter is achieved through a multiplying system whereby the W_f/P_{t4} signal for acceleration, deceleration, or steady state speed control is multiplied by a signal proportional to P_{t4} to provide the required fuel flow.

P_{t4} is sensed as follows: A metallic bellows is internally exposed to P_{t4} and the resulting force is opposed by an evacuated bellows of equal size. The net force, which is proportional to absolute burner pressure, is transmitted through a lever system to a set of rollers whose position is proportional to W_f/P_{t4}. These rollers ride between the above lever and a second lever. Thus, the force proportional to P_{t4} is transmitted through the rollers to the second lever. Any change in the roller position (W_f/P_{t4}) or the P_{t4} signals causes the upsetting of the equilibrium of this lever which results in the opening or closing of a variable or metering orifice which is supplied with regulated high pressure fuel through a fixed bleed orifice. The opening or closing of the metering orifice modulates the fuel pressure between the two orifices and this pressure is used to control the position of a piston attached to the throttle valve plunger. The motion of this piston compresses or relaxes a spring which will return the second lever to its equilibrium position.

Deceleration control is accomplished by placing a minimum stop on the W_f/P_{t4} signal. This provides a linear relationship between W_f and P_{t4} which results in blow-out free decelerations. This stop is adjustable.

Acceleration control is accomplished by placing a maximum stop on the W_f/P_{t4} signal. This stop is positioned by a two-dimensional cam which is rotated by a signal proportional to engine speed. The two-dimensional cam is so contoured as to define a schedule of W_f/P_{t4} vs. engine speed. This will permit engine accelerations which avoid the surge limits of the engine without compromising engine acceleration time.

Engine speed is sensed by an engine-driven flyweight governor of the centrifugal type which controls the movement of the speed servo piston through a pilot valve. When speed changes, the flyweight force varies and the pilot valve is positioned to meter high pressure fuel to the speed servo piston or to allow it to drain. The motion of this piston repositions the pilot valve until the speed sensing system returns to equilibrium. The position of the servo piston is indicative of actual engine speed. This piston incorporates a rack which meshes with a gear segment on the acceleration two-dimensional cam to provide the speed signal for acceleration limiting. The piston is also utilized to control selected engine speed as described below.

As the servo moves to the left, spring pressure is diminished, tending to close the flapper valve thereby allowing sufficient servo pressure to accumulate so that a new position of equilibrium is established.

Engine speed control is accomplished by comparing the actual speed as indicated by the speed servo piston to the desired speed as selected by the pilot through a power lever operated two-dimensional cam. This cam defines schedules of W_f/P_{t4} vs. power lever angle (selected speed). The deviation of desired speed from the actual speed, or the speed error, effects a change in the W_f/P_{t4} signal in the multiplying linkage. This causes an increase or decrease in fuel flow to effect the necessary speed correction. The speed setting two-dimensional cam is rotated by the pilot's power lever.

The speed setting cam incorporates a reverse power regime to schedule higher engine speeds as the power lever is retarded beyond idle into reverse. The cam includes a flat or idle portion prior to the initiation of thrust reversal.

4. Auxiliary Functions

The major auxiliary system is the throttle operated pilot valve which provides the shut-off signal to the shut-off and minimum pressure valve and a pressure signal to the manifold drain valve. The valve is positioned by a shut-off lever operated cam so that the signals are generated at the desired lever positions. The pilot valve also provides a windmill bypass feature when the shut-off valve is closed. This feature bleeds throttle valve downstream pressure to increase the throttle valve pressure drop. This allows the pressure regulating valve to continue to operate normally. Thus damage to the pumps due to excessive pressures is prevented during engine windmilling.

FUEL CONTROL (WET) - DESCRIPTION AND OPERATION

The water reset servo system consists of a reset signal switch system and the reset servo. The reset servo group consists of the speed reset lever and throttle valve rollers, a housing, a spring, a piston and a housing cover. The water reset servo functions to reset metered fuel flow to a higher value during operation of the engine water injection system. When the power lever enters a given angular position, a cam actuates a micro-switch which starts the engine water injection system. A water pressure signal is then applied to the reset servo piston. This causes the piston to reposition the speed reset lever, allowing the signal to the throttle valve multiplying lever to reset metered fuel flow to a higher value.

FUEL CONTROL (WET) - REMOVAL/INSTALLATION

1. General

A. Disconnect or remove all necessary tubes to permit fuel control removal. See Chapter 73-0, REMOVAL/INSTALLATION for tube removal and installation instructions.

NOTE: Refer to Chapter 72-0, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of the fuel control or the fuel control filter.

2. Removal/Installation of the Fuel Control

A. Removal

(1) Remove the clips securing the fuel pump-to-fuel control pressure tube. Loosen the nuts securing the tube to the elbows on the control and on the pump and remove the tube.

(2) Remove the clips securing the fuel pump-to-fuel control by-pass tube. Loosen the nuts securing the tube to the elbows on the control and on the pump and remove the tube.

(3) Remove the clip securing the fuel control-to-fuel pump return tube. Loosen the nuts securing the tube to the elbows on the control and on the pump and remove the tube.

(4) Remove the clips securing the fuel control-to-condensation trap air sensing tube. Loosen the nuts securing the tube to the connection on the condensation trap and the reducer on the fuel control. Remove the tube.

(5) On engines which incorporate the optional equipment water injection system, disconnect the nut securing the water injection control-to-fuel control water signal tube to the fuel control connector.

(6) On engines which incorporate the optional equipment oil cooler, disconnect the nut securing the fuel control-to-oil cooler tube to the fuel control elbow.

(7) On engines which do not incorporate the optional equipment oil cooler, remove the clips securing the fuel control-to-fuel pressurizing and dump valve. Loosen the nut securing the tube to the elbow, loosen the three bolts securing the tube to the control and remove the tube.

(8) Disconnect the nut securing the fuel control-to-fuel pressurizing and dump valve fuel sensing tube to the fuel control elbow.

FUEL CONTROL (WET) - REMOVAL/INSTALLATION

(9) Back-off the nut on the bolt attached to the accessory drive pad bracket; then loosen the bolt to disengage the mating part of the accessory drive pad nut assembly. See Figure 401.

(10) Supporting the fuel control, turn the control and the accessory drive pad nut assembly counterclockwise (front view) to disengage from the mating adapter attached to the accessory and component drives gearbox. Then carefully withdraw the fuel control to disengage the mating splines.

CAUTION: DO NOT LET THE WEIGHT OF THE FUEL CONTROL BE TRANSMITTED TO THE CONTROL SPLINES DURING REMOVAL.

(11) Remove the packing from the OD of the accessory drive pad.

(12) Remove the locknuts and washers securing the accessory drive pad nut assembly and the accessory drive pad to the flange of the fuel control; then remove the bolts, accessory pad, accessory pad nut assembly, and the gasket, from the fuel control mounting flange. See Figure 402.

B. Installation

NOTE: If for any reason a new or replacement fuel control is to be installed, the fuel control must be engine tested prior to flight.

(1) Position the fuel control on the bench with the mounting flange toward the operator.

(2) Position the gasket, the accessory pad nut assembly, and the accessory drive pad on the fuel control mounting flange. Secure with the bolts, washers, and locknuts, position the locknuts to the fuel control side. Tighten the locknuts to the recommended torque.

(3) Place a new packing on the flange of the accessory drive pad.

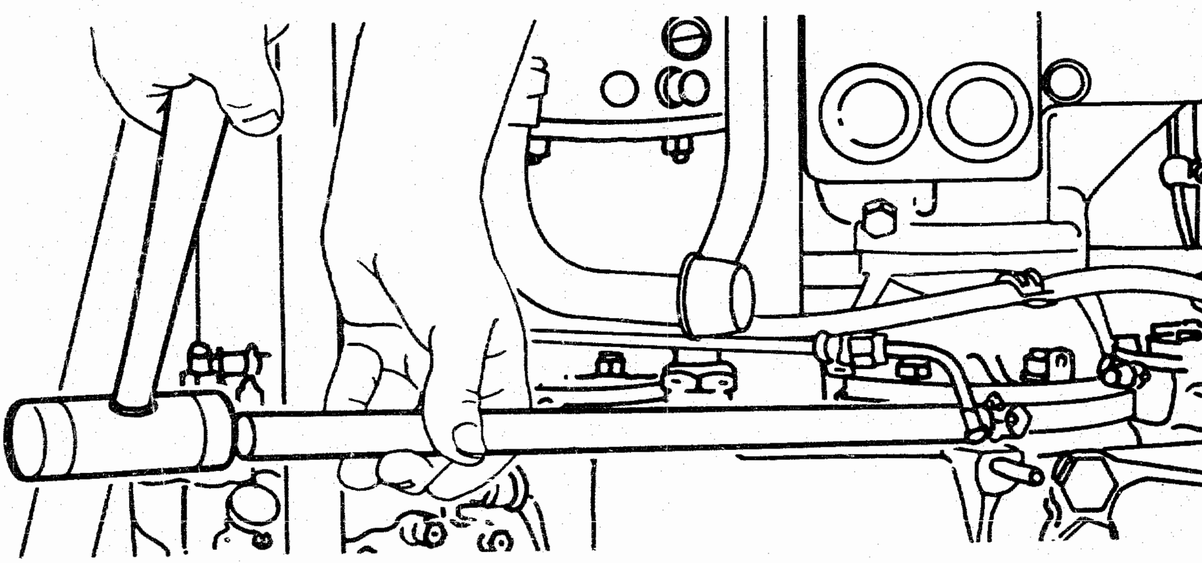
CAUTION: THE PACKING MUST GO OUTSIDE THE FINGERS OF THE PAD.

(4) Coat the fuel control shaft mating splines sparingly with Plastilube No. 3 Compound.

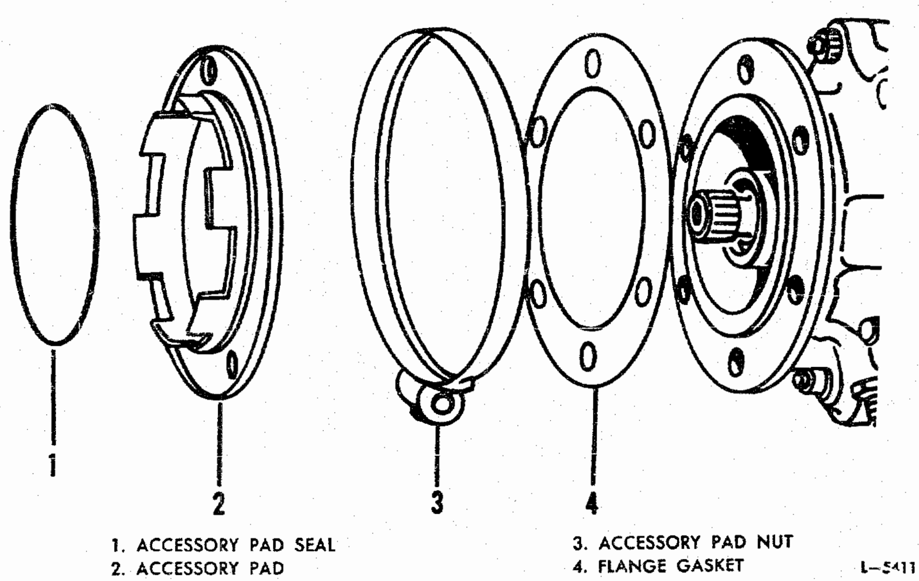
(5) Install the fuel control on the accessory and component drives gearbox assembly.

(6) Secure the control by tightening the accessory pad nut assembly to engage the threads of the adapter. Lock the nut assembly by engaging the detail nut with the bolt of the accessory drive nut bracket. Tighten the bolt to the recommended torque and lockwire.

FUEL CONTROL (WET) - REMOVAL/INSTALLATION



Loosening Mounting Adapter
Figure 401



Mounting Arrangement
Figure 402

FUEL CONTROL (WET) - REMOVAL/INSTALLATION

(7) Check for thread wear of the accessory drive pad nut bracket bolt by measuring the distance between the nut lug and attaching bracket. See Figure 403. A minimum distance of 0.625 inch, Index No. 1 is acceptable. A measurement of less than this limit is cause for rejection.

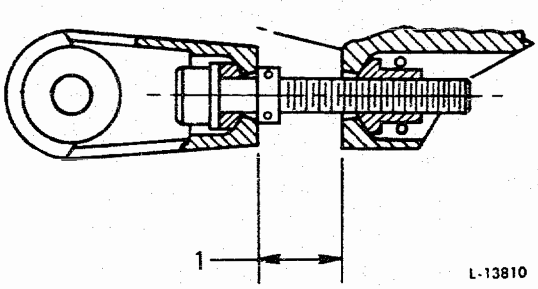
(8) Check the clearance between the inner end of the accessory drive pad nut assembly and the fuel control mounting pad of the accessory drive gearbox assembly.

NOTE: When properly installed, the clearance between the inner end of the accessory drive pad nut assembly and the fuel control mounting pad on the accessory gearbox assembly shall be 0.029 to 0.052 inch and shall not vary more than 0.010 inch when checked at each 90 degree location.

(9) Position the fuel control-to-fuel pressurizing and dump valve fuel sensing tube to the elbow on the control and secure the tube with the tube nut. Tighten the nut to the recommended torque and lockwire.

(10) On engines which do not incorporate the optional equipment oil cooler, install the clips, in the location noted at removal, on the fuel control-to-fuel pressurizing and dump valve pressure tube. Coat new seals with engine oil and install the appropriate seal in each end of the tube, then install the retainer on the valve end of the tube. Position the tube to the valve elbow and to the control outlet pad. Secure the tube nut to the elbow and install the three bolts securing the tube to the control. Tighten to the recommended torque and lockwire. Secure the clips with the screws and nuts and tighten the screws to the recommended torque.

(11) On engines which incorporate the optional equipment oil cooler, coat a new seal with engine oil and install the seal and the retainer in the end of the fuel control-to-oil cooler tube. Position the tube to the elbow on the control. Secure with the tube nut, tighten the nut to the recommended torque and lockwire.



Bracket Bolt Wear Limit
Figure 403

FUEL CONTROL (WET) - REMOVAL/INSTALLATION

(12) On engines which incorporate the optional equipment water injection system, position the water injection control-to-fuel control water signal tube to the fuel control connector and secure with the tube nut. Tighten the tube nut to the recommended torque and lockwire.

(13) Install the clips, in the same location noted at removal, on the fuel control-to-condensation trap air sensing tube. Position the tube to the connection on the condensation trap and to the reducer on the fuel control. Secure the tube with the tube nuts. Tighten the nuts to the recommended torque and lockwire.

(14) Install clips, in locations noted at removal, on the fuel control-to-fuel pump return tube. Coat new seals with engine oil and install one on each end of the tube. Install a new seal on fuel control-to-fuel pump return tube elbow. Position elbow on control, install washers and bolts, torque and lockwire. For earlier studded fuel control boss configuration install washers and locknuts and torque. Install tube, torque and lockwire tube nuts. Secure clips with screws and nuts. For threaded elbow connector configuration at fuel control, use following procedure:

(a) Coat packing, packing retainer and extended thread of fitting sparingly with petrolatum (PMC-9609) or fluid to be used in line and assemble nut, packing retainer, and packing onto fitting. Work packing retainer into bore of nut and turn nut down until packing is pushed firmly against lower thread of fitting.

(b) Install fitting into boss and at same time keep nut turning with fitting until packing contacts boss (recognized by sudden torque increase). While holding nut stationary turn fitting in (until bottom of connector contacts check valve inside of boss). Position fitting by turning out not more than one turn.

(c) While holding fitting stationary turn nut down against boss then lockwire. Obtain metal-to-metal contact between nut and boss without exceeding recommended torque 285 - 315 lb. inches. Extrusion of packing and packing retainer not permissible.

(15) Install the clips, in the locations noted at removal, on the fuel control-to-fuel pump bypass tube. Coat new seals with engine oil and install one in each end of the tube. Install a retainer in both ends, position the tube to the elbows on the control and on the pump, and secure the tube with the tube nuts. Tighten the tube nuts to the recommended torque and lockwire; then secure the clip with the screw and nut. Tighten the screw to the recommended torque.

FUEL CONTROL (WET) - REMOVAL/INSTALLATION

(16) Coat new seals with engine oil and install one in each end of the fuel pump-to-fuel control pressure tube; then install a retainer in both ends. Position the tube to the elbows on the control and on the pump; then secure with the tube nuts. Tighten the tube nuts to the recommended torque and lockwire. Install the clips, in the locations noted at removal, securing the tube. Secure the clips with the screws and nuts, and tighten the screws to the recommended torque.

3. Fuel Control Filter Screens - Removal/Installation

A. Removal

(1) Remove the retaining screw and the filter retaining rings.

(2) Pull the filter valve assembly buildup from the control.

B. Installation

(1) Coat new "O" ring seals with petrolatum, such as petrolatum (PMC-9609) or equivalent, and install them on the large screen inner diameter and the small screen inner diameter.

(2) Install the filter assembly buildup into the stepped bore of the control; then install the two filter retaining rings and the retaining screw. Tighten the screw to the recommended torque and lockwire.

4. Fuel Control Filter Screens - Disassembly/Assembly

A. Disassembly

(1) Unscrew the filter valve assembly from the flow deflector. Remove the filter valve assembly and the deflector.

B. Assembly

(1) Insert the fuel deflector inside the narrow end of the filter assembly.

(2) Coat a new seal with fuel and install it in its groove on the filter valve assembly; then insert the filter valve assembly in the opposite end of the filter assembly and thread the post on the valve into the deflector.

FUEL CONTROL (WET) - INSPECTION/CHECK

1. Burner Pressure Bellows Cavity Water Accumulation Check

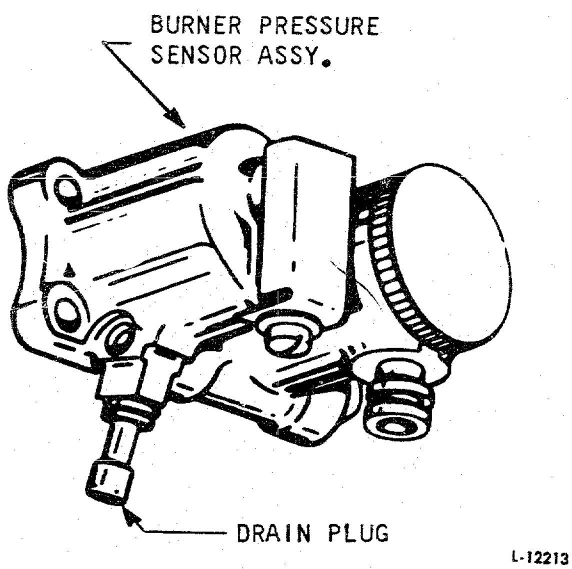
A. General

(1) Some fuel controls are provided with provisions to drain moisture from the burner pressure sensor assembly.

B. Procedure

(1) Remove the socket head seal plug from the housing and permit moisture to drain. See Figure 601.

(2) Place a new gasket seal on the socket head seal plug and reinstall in the housing.



Burner Pressure Sensor Assembly
Figure 601

FUEL CONTROL (WET) - CLEANING/PAINTING

1. Fuel Control Filter Screens

A. Procedure

(1) Slosh the filter screen assembly in a fuel solvent to remove the bulk of the contamination.

(2) Immerse the filter assembly in a caustic solution consisting of 30 percent (by weight) of sodium hydroxide in water.

(3) Soak the filter assembly for one hour; then rinse the filter assembly in running warm water.

(4) Immerse the filter assembly in warm water bath and wash thoroughly to ensure removal of all of the caustic cleaner.

(5) Apply an air jet (50 psi maximum) to the screens to remove any remaining deposits.

(6) Insert a light inside the filter screens to check the results of the cleaning procedure. Repeat the above procedure if any contaminants remain in the screens.

FUEL CONTROL (DRY) - DESCRIPTION AND OPERATION

1. General

The JFC-25 series fuel controls are designed to control the engine in either forward or reverse thrust operation under all operating conditions. Two control levers are provided; one controls the engine during forward or reverse operation and the other effects engine shutdown and starting by closing and opening a fuel shutoff valve. These controls are operated without water injection.

The fuel control accurately governs the engine steady state selected speed, acceleration, deceleration, maximum burner pressure, thrust reversal and provides a number of auxiliary signals. The speed governing system is of the proportional or droop type.

The fuel control may be considered as consisting of a metering and a computing section. The metering section alters the fuel supplied to the fuel control by the engine-driven fuel pump to provide the engine thrust output demanded by the pilot, but subject to engine operating limitations as sensed and scheduled by the control computing section. The computing section senses and combines various engine operational parameters to control the output of the metering section of the fuel control during all regimes of engine and aircraft operation.

2. Metering System

High pressure fuel is supplied to the control inlet from the engine driven pump. This fuel initially encounters the filtration system which consists of a coarse filter and a fine filter. The coarse filter protects the metering section against damage by fuel contaminants. This filter will by-pass when clogged to permit continued operation with unfiltered fuel. The fine filter protects the computing section against damage by fuel contaminants. This filter is self-cleaning through the metering system.

The fuel next encounters the pressure regulating valve. This valve is designed to maintain a constant pressure differential across the throttle valve. All high pressure fuel in excess of that required to maintain this pressure differential is bypassed to pump interstage pressure by the pressure regulating valve. The valve is servo controlled, whereby the actual pressure drop is compared to a selected pressure drop and any error is hydraulically compensated. The error resets the pressure regulating valve spring on this valve so that sufficient high pressure fuel is bypassed to maintain the selected pressure drop. The high pressure fuel, as altered by the pressure regulating valve, then passes through the metering valve. This valve consists of a contoured plunger which is positioned by the computing section of the control within a sharp-edged orifice. By virtue of the constant pressure drop maintained across the valve, the fuel flow is proportional to the position of the plunger. An adjustable stop is provided to limit the motion of the plunger in the decrease fuel direction to permit selection of the proper minimum fuel flow.

The final component to act upon the metered flow prior to its entry into the fuel manifold is the minimum pressure and shut-off valve. This valve is designed to shut off the flow of metered fuel to the engine when the pilot moves his shut-off lever to the "off" position. This generates a high pressure signal by means of the throttle operated pilot valve, which acts on the spring side of the shut-off valve, forcing it down against a seat, thus shutting off the flow of fuel to the engine. When the shut-off lever is moved into the "on" position, the high pressure signal is replaced by pump interstage pressure and when metered fuel pressure has increased sufficiently to overcome the spring force, the valve opens and fuel flow to the engine is initiated. Thereafter, the valve will provide a maximum operating pressure within the fuel control, ensuring that adequate pressure is always available for operation of the servos and valves at no less than minimum flow conditions.

3. Computing System

The computing system positions the throttle valve to control the steady state engine speed, acceleration, and deceleration. This is accomplished by using the ratio W_f/P_{t4} (the ratio of metered fuel flow to engine burner pressure) as a control parameter.

The positioning of the throttle valve by means of the W_f/P_{t4} parameter is achieved through a multiplying system whereby the W_f/P_{t4} signal for acceleration, deceleration, or steady state speed control is multiplied by a signal proportional to P_{t4} to provide the required fuel flow.

P_{t4} is sensed as follows: A metallic bellows is internally exposed to P_{t4} and the resulting force is opposed by an evacuated bellows of equal size. The net force, which is proportional to absolute burner pressure, is transmitted through a lever system to a set of rollers whose position is proportional to W_f/P_{t4}. These rollers ride between the above lever and a second lever. Thus, the force proportional to P_{t4} is transmitted through the rollers to the second lever. Any change in the roller position (W_f/P_{t4}) or the P_{t4} signals causes the upsetting of the equilibrium of this lever which results in the opening or closing of a variable or metering orifice which is supplied with regulated high pressure fuel through a fixed bleed orifice. The opening or closing of the metering orifice modulates the fuel pressure between the two orifices and this pressure is used to control the position of a piston attached to the throttle valve plunger. The motion of this piston compresses or relaxes a spring which will return the second lever to its equilibrium position.

Deceleration control is accomplished by placing a minimum stop on the W_f/P_{t4} signal. This provides a linear relationship between W_f and P_{t4} which results in blow-out free decelerations. This stop is adjustable.

Acceleration control is accomplished by placing a maximum stop on the W_f/P_{t4} signal. This stop is positioned by a two-dimensional cam which is rotated by a signal proportional to engine speed. The two-dimensional cam is so contoured as to define a schedule of W_f/P_{t4} vs. engine speed. This will permit engine accelerations which avoid the surge limits of the engine without compromising engine acceleration time.

Engine speed is sensed by an engine-driven flyweight governor of the centrifugal type which controls the movement of the speed servo piston through a pilot valve. When speed changes, the flyweight force varies and the pilot valve is positioned to meter high pressure fuel to the speed servo piston or to allow it to drain. The motion of this piston repositions the pilot valve until the speed sensing system returns to equilibrium. The position of the servo piston is indicative of actual engine speed. This piston incorporates a rack which meshes with a gear segment on the acceleration two-dimensional cam to provide the speed signal for acceleration limiting. The piston is also utilized to control selected engine speed as described below.

As the servo moves to the left, spring pressure is diminished, tending to close the flapper valve thereby allowing sufficient servo pressure to accumulate so that a new position of equilibrium is established.

Engine speed control is accomplished by comparing the actual speed as indicated by the speed servo piston to the desired speed as selected by the pilot through a power lever operated two-dimensional cam. This cam defines schedules of W_f/P_{t4} vs. power lever angle (selected speed). The deviation of desired speed from the actual speed, or the speed error, effects a change in the W_f/P_{t4} signal in the multiplying linkage. This causes an increase or decrease in fuel flow to effect the necessary speed correction. The speed setting two-dimensional cam is rotated by the pilot's power lever.

The speed setting cam incorporates a reverse power regime to schedule higher engine speeds as the power lever is retarded beyond idle into reverse. The cam includes a flat or idle portion prior to the initiation of thrust reversal.

4. Auxiliary Functions

The major auxiliary system is the throttle operated pilot valve which provides the shut-off signal to the shut-off and minimum pressure valve and a pressure signal to the manifold drain valve. The valve is positioned by a shut-off lever operated cam so that the signals are generated at the desired lever positions. The pilot valve also provides a windmill bypass feature when the shut-off valve is closed. This feature bleeds throttle valve downstream pressure to increase the throttle valve pressure drop. This allows the pressure regulating valve to continue to operate normally. Thus damage to the pumps due to excessive pressures is prevented during engine windmilling.

FUEL CONTROL (DRY) - REMOVAL/INSTALLATION

1. General

A. Disconnect or remove all necessary tubes to permit fuel control removal. See Chapter 73-0, REMOVAL/INSTALLATION for tube removal and installation instructions.

NOTE: Refer to Chapter 72-0, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of the fuel control.

2. Removal/Installation of the Fuel Control

A. Removal

(1) Remove the clips securing the fuel pump-to-fuel control pressure tube. Loosen the nuts securing the tube to the elbows on the control and on the pump and remove the tube.

(2) Remove the clips securing the fuel pump-to-fuel control by-pass tube. Loosen the nuts securing the tube to the elbows on the control and on the pump and remove the tube.

(3) Remove the clips securing the fuel control-to-fuel pump return tube. Loosen the nuts securing the tube to the elbows on the control and on the pump and remove the tube.

(4) Remove the clips securing the fuel control-to-condensation trap air sensing tube. Loosen the nuts securing the tube to the connection on the condensation trap and the reducer on the fuel control. Remove the tube.

(5) On engines which incorporate the optional equipment oil cooler, disconnect the nut securing the fuel control-to-oil cooler tube to the fuel control elbow.

(6) On engines which do not incorporate the optional equipment oil cooler, remove the clips securing the fuel control-to-fuel pressurizing and dump valve. Loosen the nut securing the tube to the elbow, loosen the three bolts securing the tube to the control and remove the tube.

(7) Disconnect the nut securing the fuel control-to-fuel pressurizing and dump valve fuel sensing tube to the fuel control elbow.

(8) Back-off the nut on the bolt attached to the accessory drive pad bracket; then loosen the bolt to disengage the mating part of the accessory drive pad nut assembly. See Figure 401.

FUEL CONTROL (DRY) - REMOVAL/INSTALLATION

(9) Supporting the fuel control, turn the control and the accessory drive pad nut assembly counterclockwise (front view) to disengage from the mating adapter attached to the accessory and component drives gearbox. Then carefully withdraw the fuel control to disengage the mating splines.

CAUTION: DO NOT LET THE WEIGHT OF THE FUEL CONTROL BE TRANSMITTED TO THE CONTROL SPLINES DURING REMOVAL.

(10) Remove the packing from the OD of the accessory drive pad.

(11) Remove the locknuts and washers securing the accessory drive pad nut assembly and the accessory drive pad to the flange of the fuel control; then remove the bolts, accessory pad, accessory pad nut assembly, and the gasket, from the fuel control mounting flange. See Figure 402.

B. Installation

NOTE: If for any reason a new or replacement fuel control is to be installed, the fuel control must be engine tested prior to flight.

(1) Position the fuel control on the bench with the mounting flange toward the operator.

(2) Position the gasket, the accessory pad nut assembly, and the accessory drive pad on the fuel control mounting flange. Secure with the bolts, washers and locknuts, position the locknuts to the fuel control side. Tighten the locknuts to the recommended torque.

(3) Place a new packing on the flange of the accessory drive pad.

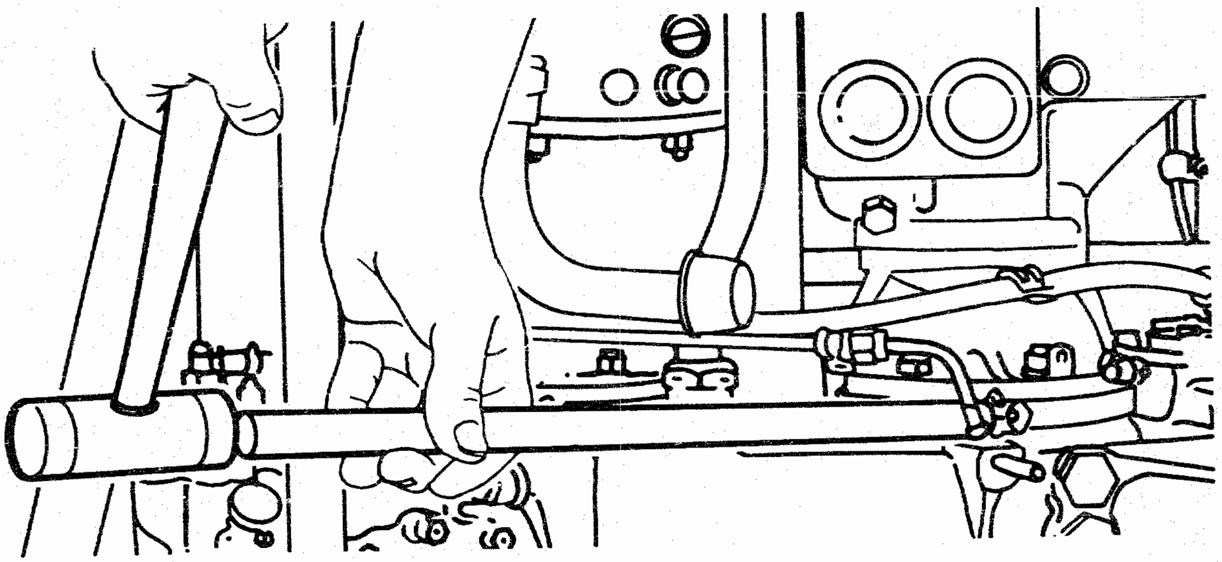
CAUTION: THE PACKING MUST GO OUTSIDE THE FINGERS OF THE PAD.

(4) Coat the fuel control shaft mating splines sparingly with Plastilube No. 3 Compound.

(5) Install the fuel control on the accessory and component drives gearbox assembly.

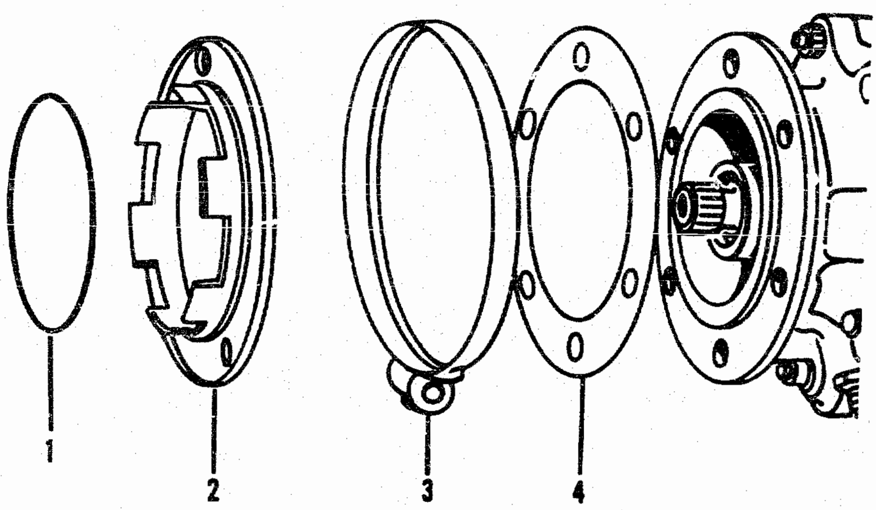
(6) Secure the control by tightening the accessory pad nut assembly to engage the threads of the adapter. Lock the nut assembly by engaging the detail nut with the bolt of the accessory drive nut bracket. Tighten the bolt to the recommended torque and lockwire.

FUEL CONTROL (DRY) - REMOVAL/INSTALLATION



Loosening Mounting Adapter

Figure 401



Mounting Arrangement

Figure 402

FUEL CONTROL (DRY) - REMOVAL/INSTALLATION

(7) Check for thread wear of the accessory drive pad nut bracket bolt by measuring the distance between the nut lug and attaching bracket. See Figure 403. A minimum distance of 0.625 inch, Index No. 1 is acceptable. A measurement of less than this limit is cause for rejection.

(8) Check the clearance between the inner end of the accessory drive pad nut assembly and the fuel control mounting pad of the accessory drive gearbox assembly.

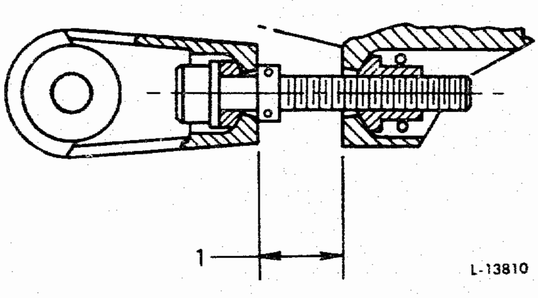
NOTE: When properly installed, the clearance between the inner end of the accessory drive pad nut assembly and the fuel control mounting pad on the accessory gearbox assembly shall be 0.029 to 0.052 inch and shall not vary more than 0.010 inch when checked at each 90 degree location.

(9) Position the fuel control-to-fuel pressurizing and dump valve fuel sensing tube to the elbow on the control and secure the tube with the tube nut. Tighten the nut to the recommended torque and lockwire.

(10) On engines which do not incorporate the optional equipment oil cooler install the clips, in the location noted at removal, on the fuel control-to-fuel pressurizing and dump valve pressure tube. Coat new seals with engine oil and install the appropriate seal in each end of the tube; then install the retainer on the valve end of the tube. Position the tube to the valve elbow and to the control outlet pad. Secure the tube nut to the elbow and install the three bolts securing the tube to the control. Tighten to the recommended torque and lockwire. Secure the clips with the screws and nuts and tighten the screws to the recommended torque.

(11) On engines which incorporate the optional equipment oil cooler, coat a new seal with engine oil and install the seal and the retainer in the end of the fuel control-to-oil cooler tube. Position the tube to the elbow on the control. Secure with the tube nut, tighten the nut to the recommended torque and lockwire.

(12) Install the clips, in the same location noted at removal on the fuel control-to-condensation trap sensing tube. Position the tube to the connection on the condensation trap and to the reducer on the fuel control. Secure the tube with the tube nuts. Tighten the nuts to the recommended torque and lockwire.



Bracket Bolt Wear Limit

Figure 403

FUEL CONTROL (DRY) - REMOVAL/INSTALLATION

(13) Install clips, in locations noted at removal on the fuel control-to-fuel pump return tube. Coat new seals with engine oil and install one on each end of tube. Install a new seal on fuel control-to-fuel pump return tube elbow. Position elbow on control, install washers and bolts, torque and lockwire. For earlier studded fuel control boss configuration install washers and locknuts and torque. Install tube, torque and lockwire tube nuts. Secure clips with screws and nuts. For threaded elbow connector configuration at fuel control, use following procedure:

(a) Coat packing, packing retainer and extended thread of fitting sparingly with petroaltum (PMC-9609) or fluid to be used in line and assemble nut, packing retainer, and packing onto fitting. Work packing retainer into bore of nut and turn nut down until packing is pushed firmly against lower thread of fitting.

(b) Install fitting into boss and at same time keep nut turning with fitting until packing contacts boss (recognized by sudden torque increase). While holding nut stationzry turn fitting in (until bottom of connector contacts check valve inside of boss). Position fitting by turning out not more than one turn.

(c) While holding fitting stationary turn nut down against boss then lockwire. Obtain metal to metal contact between nut and boss without exceeding recommended torque, 285 - 315 lb. inches. Extrusion of packing and packing retainers, is not permissible.

(14) Install the clip in the location noted at removal, on the fuel control-to-fuel pump by-pass tube. Coat new seals with engine oil and install one in each end of the tube. Install a retainer in both ends, position the tube to the elbows on the control and on the pump, and secure the tube with the tube nuts. Tighten the tube nuts to the recommended torque and lockwire; then secure the clip with the screw and nut. Tighten the screw to the recommended torque.

(15) Coat new seals with engine oil and install one in each end of the fuel pump-to-fuel control pressure tube; then install a retainer in both ends. Position the tube to the elbows on the control and on the pump, then secure with the tube nuts. Tighten the tube nuts to the recommended torque and lockwire. Install the clips, in the locations noted at removal securing the tube. Secure the clips with the screws and nuts, and tighten the screws to the recommended torque.

3. Fuel Control Filter Screens - Removal/Installation

A. Removal

(1) Remove the retaining screw and the filter retaining rings.

(2) Pull the filter valve assembly buildup from the control.

B. Installation

(1) Coat new "O" ring seals with petrolatum, such as PMC 9609 or equivalent, and install them on the large screen inner diameter and the small screen inner diameter.

(2) Install the filter assembly buildup into the stepped bore of the control; then install the two filter retaining rings and the retaining screw. Tighten the screw to the recommended torque and lockwire.

4. Fuel Control Filter Screens - Disassembly/Assembly

A. Disassembly

(1) Unscrew the filter valve assembly from the flow deflector. Remove the filter valve assembly and the deflector.

B. Assembly

(1) Insert the fuel deflector inside the narrow end of the filter assembly.

(2) Coat a new seal with fuel and install it in its groove on the filter valve assembly; then insert the filter valve assembly in the opposite end of the filter assembly and thread the post on the valve into the deflector.

FUEL CONTROL (DRY) - ADJUSTMENT/TEST

1. Fuel Control Linkage Adjustment (JT3D-1 Douglas, JT3D-3 Douglas, and JT3D-3B Douglas)

A. Procedure

(1) Fabricate a fuel control linkage adjusting gage as shown in Figure 501. Identify details as indicated in figure index. This gage is not used when non-adjustable shutoff control arms are installed.

(2) Position the gage pins in the center arm on the fuel control and in the center of the inner lever arm shaft attached to the stub shaft on the intermediate case front flange.

(3) Adjust the length of the gage, as necessary, and lock in place.

(4) Install the jamnuts on the threaded ends of the shut-off lever rods as noted below.

(5) Assemble the shut-off lever rods to the adjuster and centralize the adjuster.

NOTE: These instructions do not apply to one-piece rigid (non-adjustable) shut-off lever rods.

(6) Position the bends in both rods in the same direction.

(7) Install the pins on the gage (set above) into the holes in the ends of both rods, turning the adjusters, as necessary, to adjust the length of the assembly to fit the gage.

(8) When the pins of the gage fit without interference, tighten and torque the jamnuts to 65-85 pound-inches.

(9) Install the above assembled details to the inner arm on the fuel control and inner arm on the power lever arm assembly (rod marked "L.H. thread" to fuel control) with the bends in the rods down.

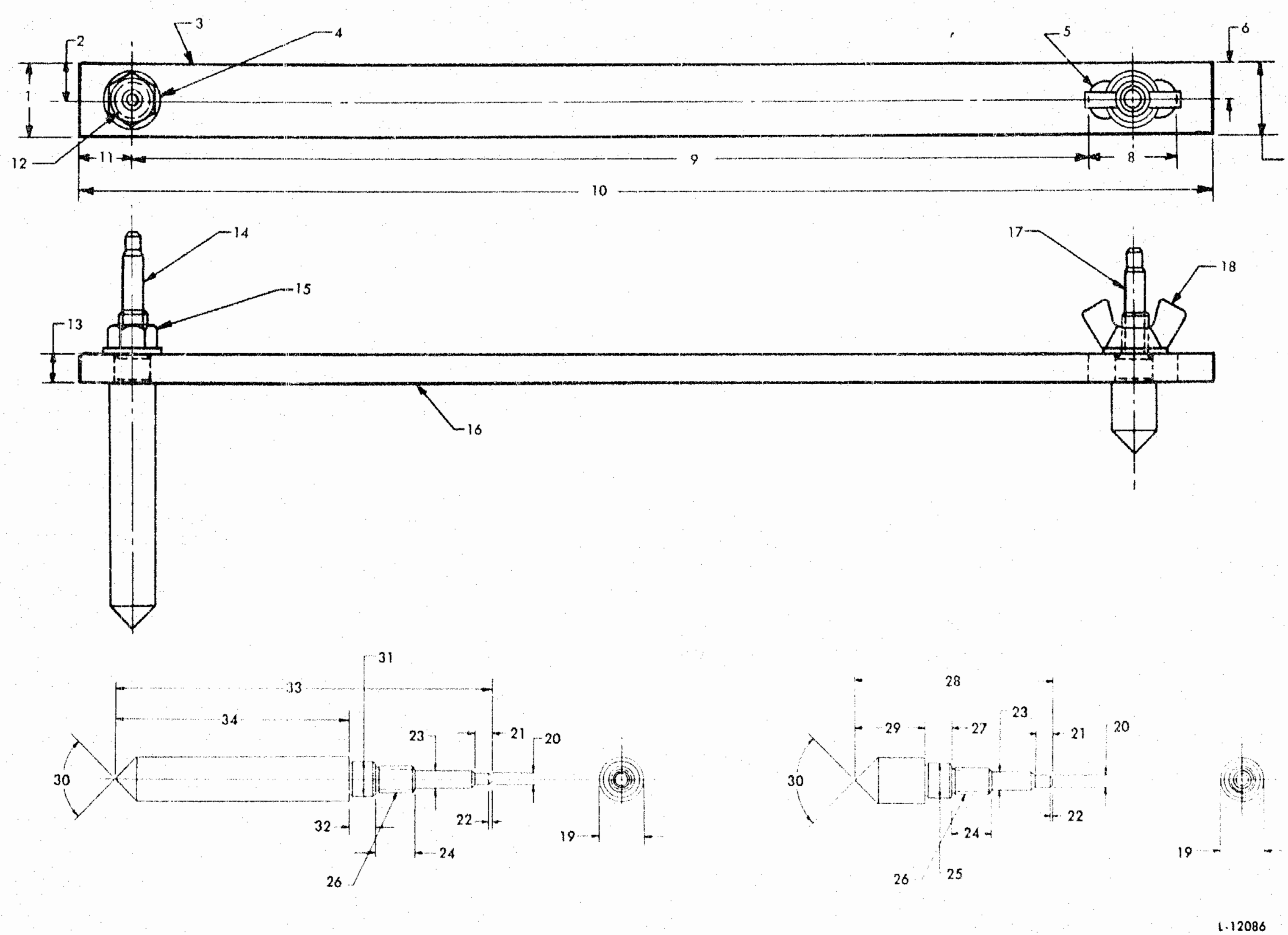
(10) Secure in place with the bolts. Tighten the bolts fingertight.

(11) Install the jamnuts on the threaded ends of the power lever rods as noted below.

(12) Assemble the rods to the adjusters and centralize the adjusters. Position the bends in both rods in the same direction.

(13) Set the length of the assembly in the same manner as indicated for the shut-off lever clevises.

(14) Using the same gage with the same setting, tighten the jamnut to a torque of 65-85 pound-inches.



Fuel Control Linkage Gage

Figure 501

FUEL CONTROL (DRY) - ADJUSTMENT/TEST

1. One Inch.
2. 1/2 Inch.
3. Detail No. 1 Bar - Machine Steel 3/8 X 1 X 17 1/2 Inches (1 Req'd).
4. Detail No. 2 Washer - Steel 3/8 Inch Standard (2 Required).
5. Radius (2 Places).
6. 1/4 Inch.
7. 1/2 Inch Fit For Detail No. 5 (Index No. 17).
8. 1 1/4 Inch.
9. 15 Inches.
10. 17 1/2 ± 1/16 Inches.
11. 3/4 Inch.
12. 1/2 Inch Ream Through.
13. 3/8 Inch.
14. Detail No. 3 Pin (Large) Machine Steel (1 Req'd) 5/8 Dia X 5 31/64.
15. Detail No. 4 Hexagonal Nut - 3/8 - 16 (Steel).
16. This Surface To Be Flat Within 0.005 Inch.
17. Detail No. 5 Pin (Short) Machine Steel (1 Req'd) 5/8 Dia X 2 53/64.
18. Detail No. 6 Wingnut - 3/8 - 16 (Steel) 1 Required.
19. 5/8 Inch Diameter.
20. Finish To A Roughness Value (AA) of 32 $0.208 \pm {}^{.000}_{.002}$ Inch Diameter - See Index No. 23.
21. 1/4 Inch.
22. 1/32 Inch X 45°.
23. 0.248 Inch Diameter. Finish To A Roughness Value (AA) of 32. 0.208 Inch Diameter and 0.248 Inch Diameter To Be Concentric With Each Other Winin 0.001 Inch and With the 90° Point (Index No. 30) Within 0.005 Inch.
24. 9/16 Inch.
25. 1/2 Inch Diameter Slip Fit In Detail No. 1 (Index No. 3).
26. 3/8 - 16 Thread.
27. 11/32 Inch.
28. 2 53/64 Inches.
29. 1.000 ± 0.005 Inch.
30. 90 Degree Finish to A Roughness Value (AA) of 32.
31. 1/2 Inch Diameter Press Fit In Detail No. 1 (Index No. 3).
32. 11/32 Inch.
33. 5 31/64 Inch.
34. 3.418 ± 0.005 Inches.

Key to Figure 501

FUEL CONTROL (DRY) - ADJUSTMENT/TEST

(15) Install the above assembled details to the remaining arm on the fuel control (rod marked "L.H. thread" to the fuel control). Place the bends in the rods down. Tighten the bolts fingertight.

(16) Position the inner fuel control arm at the OFF position.

(17) Hold the arm against the stop on the control and adjust the screw stop at the power lever assembly end to contact the inner arm.

(18) Turn the screw stop in, one additional turn; then tighten the locknut.

(19) Move the inner arm on the fuel control to FULL ON position. Hold the arm against the stop on the control and adjust the screw stop at the power lever assembly end to contact the inner arm.

(20) Turn the screw stop in, one additional turn; then tighten the locknut.

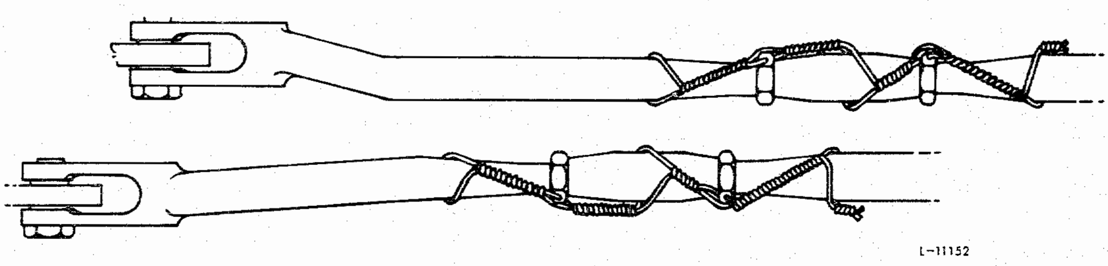
NOTE: After setting the above stop screws, the lever on the fuel control will not contact the stops on the fuel control.

(21) Repeat the above procedure for the outer arm of the fuel control, starting from full reverse position on the control and moving to full forward position.

(22) Tighten and torque the jamnuts on the four stop screws to 10-15 pound-inches. Lockwire the screw stop jamnuts and screw stops.

(23) Lockwire the rods, jamnuts, and adjusters as shown in Figure 502.

(24) Tighten the bolts securing the rods to the lever arms to a torque of 65-80 pound-inches.



Lockwiring the Power Lever Linkage
Adjusters (Turnbuckles)

Figure 502

FUEL CONTROL (DRY) - INSPECTION/CHECK

1. Burner Pressure Bellows Cavity Water Accumulation Check

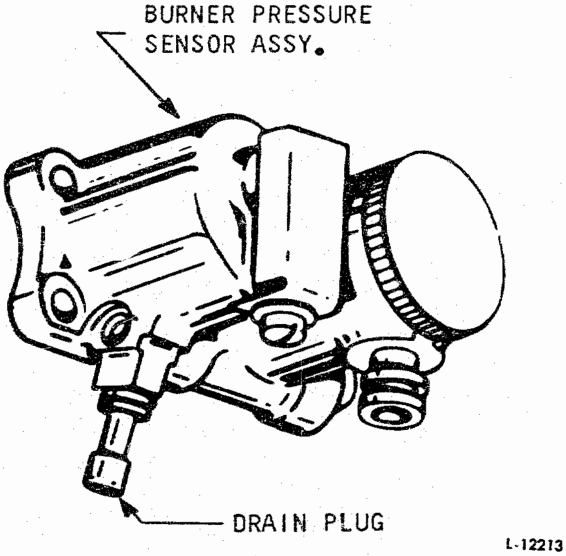
A. General

(1) Some fuel controls are provided with provisions to drain moisture from the burner pressure sensor assembly.

B. Procedure

(1) Remove the socket head seal plug from the housing and permit moisture to drain. See Figure 601.

(2) Place a new gasket seal on the socket head seal plug and reinstall in the housing.



Burner Pressure Sensor Assembly

Figure 601

FUEL CONTROL (DRY) - CLEANING/PAINTING

1. Fuel Control Filter Screens

A. Procedure

(1) Slosh the filter screen assembly in a fuel solvent to remove the bulk of the contamination.

(2) Immerse the filter assembly in a caustic solution consisting of 30 percent (by weight) of sodium hydroxide in water.

(3) Soak the filter assembly for one hour; then rinse the filter assembly in running warm water.

(4) Immerse the filter assembly in warm water bath and wash thoroughly to ensure removal of all of the caustic cleaner.

(5) Apply an air jet (50 psi maximum) to the screens to remove any remaining deposits.

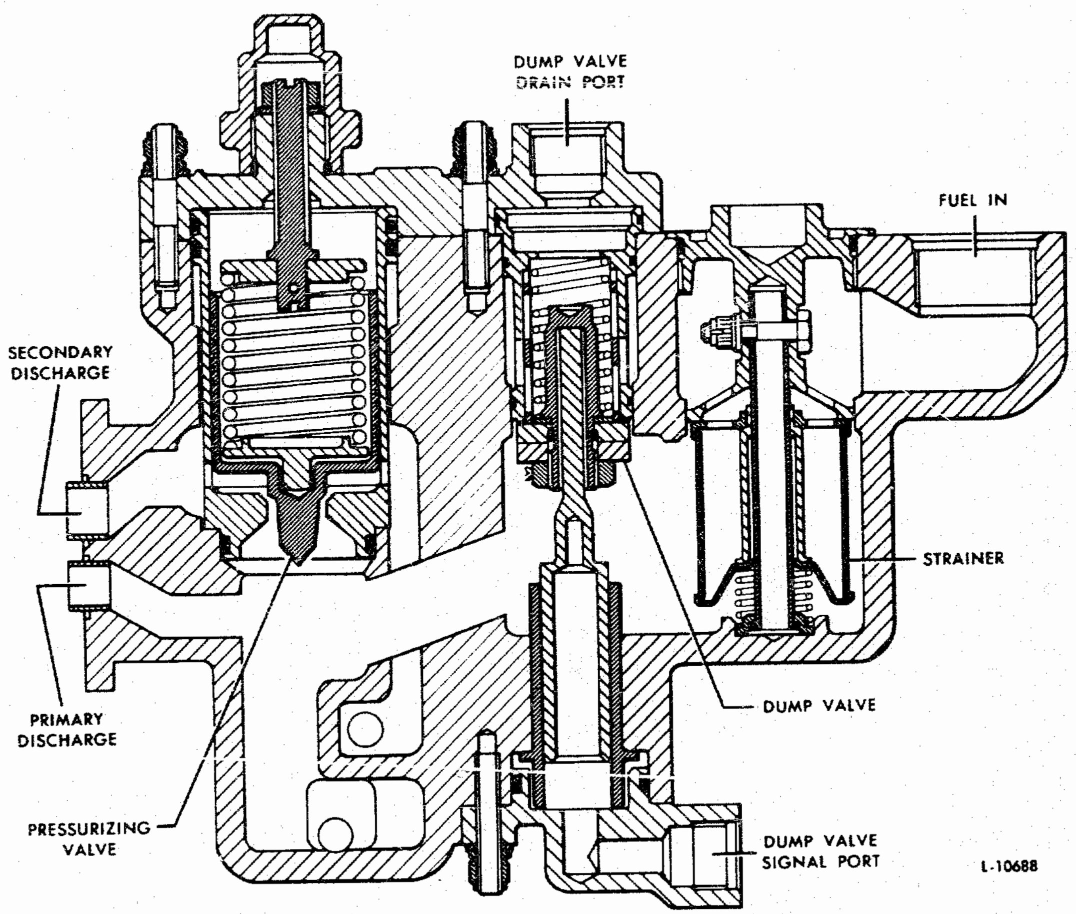
(6) Insert a light inside the filter screens to check the results of the cleaning procedure. Repeat the above procedure if any contaminants remain in the screens.

FUEL PRESSURIZING AND DUMP VALVE - DESCRIPTION AND OPERATION

1. General

The fuel pressurizing and dump valve, which is downstream of the engine fuel control, is connected to the engine fuel manifold to which it discharges its fuel via two paths, the primary and the secondary fuel manifolds. The essential parts of the fuel pressurizing and dump valve (see Figure 1) include a 200 mesh fuel inlet screen, a manifold dump or drain valve, and a pressurizing or flow-dividing valve.

The fuel pressurizing and dump valve is located on the outside of the engine diffuser case at its rear bottom center. Four long bolts hold the valve body, inlet spacer assembly and fuel inlet fitting together and fasten them to the diffuser case.



Fuel Pressurizing and Dump Valve Schematic
Figure 1

FUEL PRESSURIZING AND DUMP VALVE - DESCRIPTION AND OPERATION

2. Inlet Screen

The 200 mesh fuel inlet screen, which filters all fuel before its introduction to the fuel nozzles, is spring-loaded on its seat. This arrangement permits by-pass flow at 10 to 20 psi around it in the event of screen clogging.

3. Dump or Drain Valve

The manifold dump or drain valve is a two-sided, nylon-disk poppet valve which is opened by the force of a spring and is closed by a hydraulically-actuated piston sliding in a sleeve. Pump discharge pressure directed by the fuel control throttle operated pilot valve is applied to the chamber behind the piston when the pilot valve is moved out of the "OFF" position. This pressure is sufficiently high to move the piston and dump valve against the spring force and thereby holds the dump valve in the closed position during engine operation. When the pressure behind the actuating piston is reduced to fuel control boost pressure by movement of the throttle operated pilot valve to the "OFF" position, the spring forces the dump valve into the open or dump position, thus permitting the primary fuel manifold to drain overboard. The difference between the area of the dump valve proper and the actuating piston exposed to primary manifold pressure prevents the dump valve from opening until the primary manifold has decreased to a value below the normal minimum operating value.

4. Pressurizing Valve

The fuel pressurizing valve consists of a spring-loaded, stepped-area piston and cylinder assembly. One end of the large diameter cylinder contains an orifice and valve seat within which the contoured small-diameter, pintle-type piston operates, and against which it seals to shut off fuel flow to the secondary manifold. The spring end of the piston in the large diameter cylinder is vented to the secondary fuel manifold. When primary chamber pressure which surrounds the pintle becomes sufficient (250 psig for use with non aerated fuel nozzles or 400 psig for aerated fuel nozzles) to overcome the force due to the spring plus burner pressure (the same as secondary manifold pressure until the valve opens) the valve is forced open, and fuel flows in the large diameter cylinder and through fixed area radial slots in the lower end of the cylinder to the secondary manifold. As the fuel flow increases the pressure drop across these radial slots increases, which creates a pressure drop across the large piston adding to that across the pintle piston to help overcome the spring force. This stepped-area piston produces the effect of a negative spring-rate, thereby decreasing the pressure difference between the primary and secondary manifolds as fuel increases. The contour of the pintle is designed to divide the primary and secondary flows to give satisfactory nozzle spray characteristics at all fuel flow conditions.

FUEL PRESSURIZING AND DUMP VALVE - REMOVAL/INSTALLATION

1. General

A. Disconnect or remove all necessary tubes to permit fuel pressurizing and dump valve removal. See Chapter 73-0, Removal/Installation for tube removal and installation instructions.

NOTE: Refer to Chapter 72-0, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of the fuel pressurizing and dump valve or the screen assembly.

2. Fuel Pressurizing and Dump Valve

A. Removal

(1) For engines which incorporate optional equipment oil cooler, disconnect tube nut which secures oil cooler-to-fuel pressurizing and dump valve tube to valve elbow.

(2) Disconnect tube nut which secures fuel control-to-fuel pressurizing and dump valve fuel sensing tube to valve elbow.

NOTE: On engines incorporating SB 3721, fuel control-to-fuel pressurizing and dump valve fuel sensing tube has been removed.

(3) Disconnect tube nut which secures condensation trap-to-fuel pressurizing and dump valve air sensing tube to valve elbow.

(4) For engines which do not incorporate optional equipment oil cooler disconnect tube nut which secures fuel control-to-pressurizing and dump valve pressure tube to valve elbow.

(5) Remove bolts securing fuel pressurizing and dump valve to diffuser case (inlet spacer assembly); then remove dump valve.

(6) Remove screws securing inlet spacer assembly distributor; then remove assembly.

B. Installation

NOTE: Engines converted to smokeless burner configuration require use of new fuel pressurizing and dump valve that must only be used in this new configuration even though old and new valves are physically interchangeable.

(1) Preformed Packing Configuration

(a) Coat new seals (small) with engine oil and install the seals on each ferrule of two primary and burner pressure openings in inlet spacer.

FUEL PRESSURIZING AND DUMP VALVE - REMOVAL/INSTALLATION

(b) Coat new seals (large) with engine oil and install seals on each ferrule of two secondary opening openings in inlet spacer.

(c) Install inlet spacer assembly on fuel manifold adapter attached to diffuser case at 6 o'clock position. Secure inlet spacer with screws and tighten them to recommended torque and lockwire.

(d) Coat new seals with engine oil; then place a seal on each ferrule in primary and secondary openings in mounting flange of fuel pressurizing and dump valve assembly.

(e) Carefully install dump valve over inlet spacer assembly, aligning primary and secondary fuel outlets and mating mounting holes.

(f) Install washers and bolts securing fuel pressurizing and dump valve to inlet spacer assembly. Tighten bolts to recommended torque and lock-wire.

NOTE: Pressure check pressurizing and dump valve for leakage. See 72-0, ENGINE - ADJUSTMENT TEST.

(2) Chevron type seal configuration.

(a) Install gaskets in two primary and two secondary fuel passages, and in burner pressure passage of adapter located on fuel manifold mating side of fuel inlet adapter.

(b) Install fuel manifold inlet adapter through fuel pressurizing and dump valve mount pad on bottom of diffuser case, engaging dowels in dowel holes of manifold adapters.

(c) Secure fuel manifold inlet adapter to manifold adapters with screws.

(d) Install gaskets in cavities located around primary and secondary bush-ings of inlet adapter mating face on fuel pressurizing and dump valve.

(e) Position fuel pressurizing and dump valve in fuel manifold inlet adapter engaging bushing in mating holes. Secure fuel pressurizing and dump valve to diffuser case with bolts. Torque and lockwire bolts.

(3) For engines which do not incorporate optional equipment oil cooler, coat new seal with engine oil and install seal on end of fuel control-to-pressurizing and dump valve pressure tube. Install a retainer on end of tube. Position tube to elbow on valve and secure with tube nut. Tighten nut to recommended torque and lockwire.

(4) For engines which incorporate optional equipment oil cooler, coat new seal with engine oil and install seal on end of oil cooler-to-fuel pressurizing and dump valve tube. Install a retainer on end of tube. Position tube to elbow on valve and secure with tube nut. Tighten nut to recommended torque and lockwire.

(5) Position condensation trap-to-fuel pressurizing and dump valve air sensing tube to elbow on valve and secure with tube nut. Tighten nut to recommended torque and lockwire.

(6) Position fuel control-to-fuel pressurizing and dump valve fuel sensing tube to elbow on valve and secure with tube nut. Tighten nut to recommended torque and lockwire.

NOTE: On engines incorporating SB 3721, fuel control-to-fuel pressurizing and dump valve full sensing tube has been removed.

3. Fuel Pressurizing and Dump Valve Fuel Screen - Disassembly/Assembly

NOTE: On Boeing engines plate on fireseal must be removed to permit access to strainer chamber plug.

A. Disassembly

(1) Loosen and remove strainer chamber plug and attached screen assembly.

(2) Remove cotterpin, nut, and bolt from plug and separate plug, screen, packing, spring, spring seat and strainer rod.

B. Assembly

(1) Place spring seat, spring, screen, and strainer chamber plug on strainer rod and secure these parts with bolt, nut, and cotterpin.

(2) Position body on bench with pressurizing valve, dump valve, and strainer chambers facing operator.

(3) Install a new packing ("O" ring seal), coated with petrolatum, such as PMC 9609 or equivalent, on strainer chamber plug. Insert strainer chamber and plug assembly into body, locating seat in recess in bottom of chamber. Tighten plug to recommended torque and lockwire.

FUEL PRESSURIZING AND DUMP VALVE - INSPECTION/CHECK

1. Fuel Pressurizing and Dump Valve Screen

   A. Inspect screen for evidence of broken mesh or loose braze. Replace screen, if necessary.

2. Fuel Pressurizing and Dump Valve

   A. Visually check fuel pressurizing and dump valve for leakage following installation. See 73-5-1, Fuel Manifold - Inspection/Check.

3. Fuel Pressurizing and Dump Valve Leakage Check
   See Figure 601.

   A. Fuel leakage check

      (1) Insert PWA 31610 (Delevan) or PWA 44023 (Excello) Seal into each PWA 8299 Clamp.

      (2) Position fuel nozzle clamps on fuel manifold clusters and secure by turning hand knobs of clamp bars.

      NOTE: Do not tighten to full extent of spring travel.

      (3) Remove secondary tap plug and attach PWA 8566 Adapter, connect to return line (11) of test stand; then close shut-off valve (12).

      (4) Connect PWA 8496 Adapter to fuel inlet elbow (6) on pressurizing and dump valve.

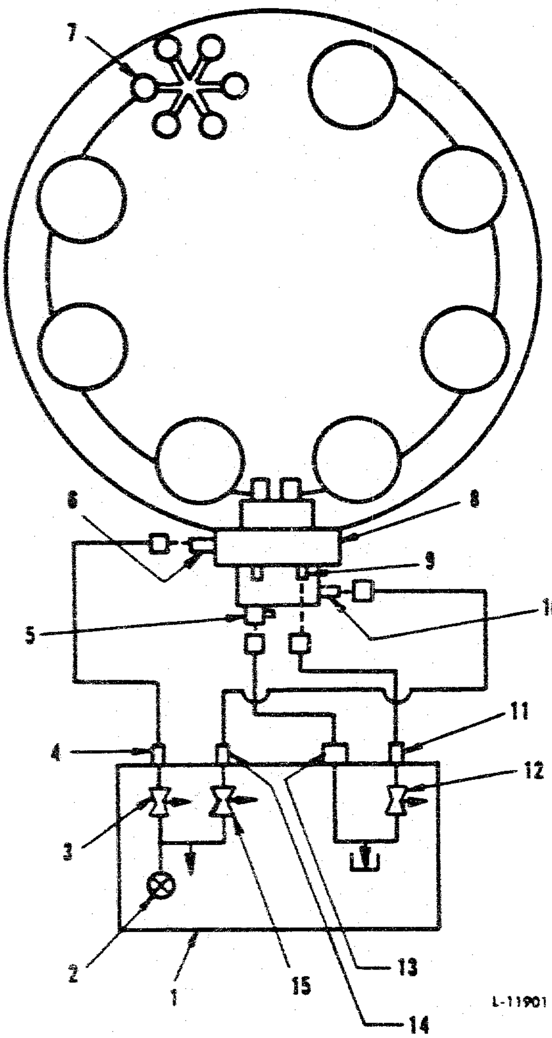
      (5) Attach PWA 10723 Signal Adapter to dump signal connector (10) on pressurizing and dump valve.

      (6) Attach PWA 10719 Adapter to fuel pressurizing and dump valve overboard drain port.

      (7) Proceed to pressure test by closing shut-off valve (3) and opening shut-off valve (15).

      (8) Start pump on test stand and adjust fuel pressure to 200 psig or slightly above by adjusting by-pass valve (2).

      NOTE: All lines and equipment necessary to perform this test must be clean. Test fluid shall be approved calibrating fluid, and must be adequately filtered to prevent contamination of fuel system.



1. TEST STAND.
2. BY-PASS VALVE.
3. NO. 1 FUEL SHUT-OFF VALVE.
4. NO. 1 FUEL SUPPLY.
5. NO. 1 RETURN DUMP.
6. INLET ELBOW.
7. NOZZLES.
8. PRESSURIZING AND DUMP VALVE.
9. SECONDARY PRESSURE TAP.
10. SIGNAL ELBOW.
11. NO. 2 FUEL RETURN.
12. FUEL RETURN SHUT-OFF VALVE.
13. NO. 1 FUEL RETURN.
14. NO. 2 FUEL SUPPLY.
15. NO. 2 FUEL SUPPLY SHUT-OFF VALVE.

Pressurizing and Dump Valve Leakage Check

Figure 601

FUEL PRESSURIZING AND DUMP VALVE - INSPECTION/CHECK

(9) Open shut-off valve (3) slowly maintaining pressure of at least 200 psig.

(10) Bleed air from fuel manifold by lifting one cap, from each half of manifolds, from two nozzles furthest from dump valve (8).

(11) Increase fuel pressure to 600 psig by adjusting by-pass valve (2). Maintain this pressure for five minutes.

(12) Inspect for leakage at following locations:

(a) Joints between halves of fuel manifold.

(b) Between fuel manifold and distributor.

(c) Between distributor and dump valve.

(d) At burner pressure standpipe on fuel manifold and burner pressure connection on dump.

(13) At end of five minute test period, check overboard drain connection for leakage.

NOTE: Maximum permissible leakage from drain connection is five cc per minute.

(14) To drain assembly after test check, connect dump line (13) and open return shut-off valve (12) and then reduce pressure from test stand and manifold as much as possible by fully opening all valves and shutting off test stand for approximately one minute.

(15) Close shut-off valve (3) and start test stand to actuate syphoning action.

(16) Lift one cap, from each half of manifolds, from two nozzle furthest from dump valve to allow fluid trapped in manifolds to drain out.

NOTE: Flowmeter sight gage on test stand will indicate when fluid is completely drained from manifolds and dump valve.

(17) Disconnect PWA 8566 Adapter and install secondary pressure tap plug. Tighten plug to recommended torque and lockwire.

B. PS4 leakage check at fuel manifold adapter.

NOTE: It is not necessary to cap PS4 sensing probe.

(1) Connect source of clear dry air at 20 - 120 psig to PS4 fitting on fuel manifold inlet adapter.

FUEL PRESSURIZING AND DUMP VALVE - INSPECTION/CHECK

(2) Apply solution of soap and water at parting line of fuel manifold adapter (left and right) inside the diffuser case and fuel manifold inlet adapter on outside of diffuser case.

(3) Apply air pressure and observe for leakage.

(4) Leakage, as evidenced by bubbles, is not acceptable.

NOTE: Fuel and PS4 chevron seals shall be replaced with new seals each time fuel manifold inlet adapter is removed from diffuser case.

4. Numerical Tool List

PWA 8299-16 (Superseded by PWA 31610, 31611)	Seal
PWA 8299 (Supersedes PWA 8299-50)	Clamp
PWA 8299-50 (Superseded by PWA 8299)	Clamp
PWA 8496	Adapter
PWA 8566	Adapter
PWA 10719	Adapter
PWA 10723	Adapter
PWA 31610 (Supersedes PWA 8299-16)	Seal
PWA 31611 (Supersedes PWA 8299-16) (Superseded by PWA 49023)	Seal
PWA 44023 (Supersedes PWA 31611)	Seal

FUEL PRESSURIZING AND DUMP VALVE - CLEANING/PAINTING

1. Fuel Pressurizing and Dump Valve Screen

A. Clean the screen in solvent and dry with a light air blast.

NOTE: Lint clogged screens can be cleaned in the following manner:

(1) Immerse the screen in a saturated solution of 1 liter of concentrated sulfuric acid (commercial grade) and 20 grams of sodium dichromate (technical grade) for a period of one minute. It may be necessary to heat the solution to 150°F (66°C) in order to dissolve the crystals.

(2) Remove the acid solution from the screen by rinsing it thoroughly in clean water and drying with compressed air.

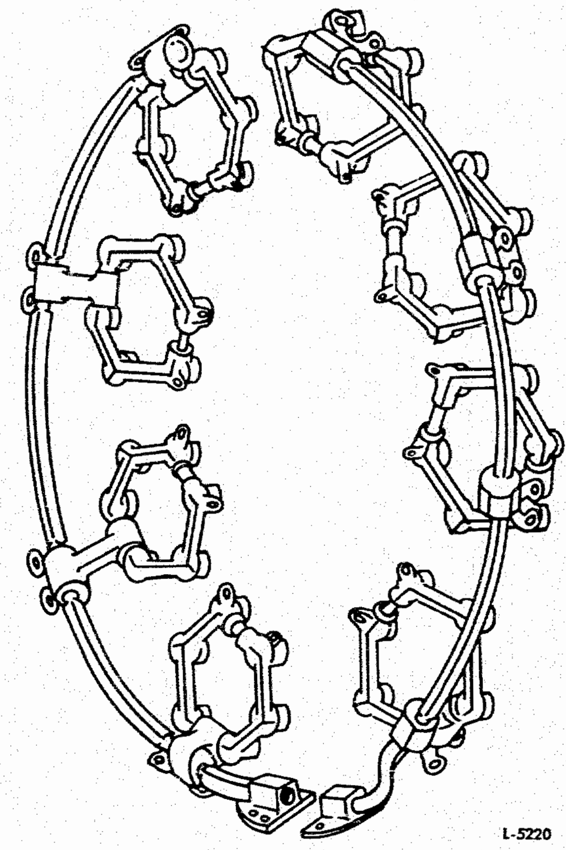
(3) Repeat steps (1) and (2) if any lint remains.

WARNING: AT CONCLUSION OF THE CLEANING PROCEDURE, DESTROY OR PROPERLY STORE THE PREPARED CLEANING SOLUTION.

FUEL MANIFOLD - DESCRIPTION AND OPERATION

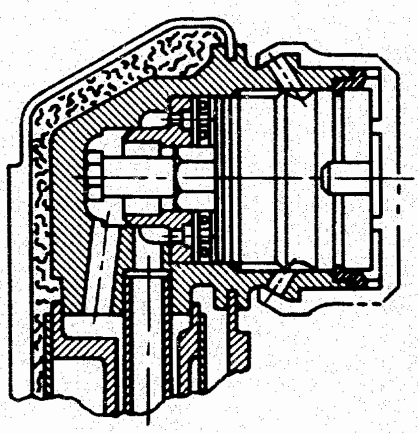
1. Description

The fuel manifold (see Figure 1) is split in two sections. Each manifold half consists of two tubes leading to four spray nozzle clusters. The outer tube carries the primary or idling fuel. The secondary, or main fuel is carried in the inner tube (see Figure 2). This is done to eliminate coking of the secondary fuel from engine heat when idling. The flowing primary fuel will keep the inner tube cool. Each nozzle cluster also has a pair of concentric tubes in it. These tubes tap into the manifold tubes and each one of the pair feeds three nozzles. At the manifold end of the number four cluster, there is a small probe tube mounted. This is the combustion chamber pressure (P_b) sensing probe that fits through a hole in the number four combustion chamber. No fuel flows through the probe, which is connected to the manifold flange by a tube separate from the manifold.



Fuel Manifold

Figure 1



Nozzle Installed in Manifold

Figure 2

FUEL MANIFOLD - REMOVAL/INSTALLATION

1. General

NOTE: Manifolds should be removed from engine for accomplishment of maintenance procedures.

To avoid distortion during removal, installation, and transportation, fuel manifolds must be handled with care.

2. Removal/Installation of the Fuel Manifold

NOTE: Refer to Chapter 72-0, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of the fuel manifold.

A. Removal

(1) Slide the combustion section outer case rearward, and remove the combustion chambers from the engine. Refer to Chapter 72, Engine, for detail combustion chamber removal instructions.

(2) Remove the pressurizing and dump valve.

(3) Straighten the tabs and remove the nuts securing the right and left manifold; then remove the combustion chamber positioning brackets.

(4) Pry the tabs from the lockring holes and remove the inner tabwashers.

(5) Remove the fuel manifold adapter retaining bolts.

(6) Remove the manifolds and place them in the PWA-8376 Fixture. Make certain that the fuel nozzles are adequately protected against damage or entry of dirt into the nozzle openings.

(a) Place PWA-17591 Support under each of three short ears on manifold assembly.

(b) Insert bolt and washer through ear and thread into support.

(c) Mate holes in outer end of support with pads on PWA-8376 Holding Fixture. For manifolds incorporating inner mounting lug bushing use PWA-17921 Holding Fixture.

NOTE: After incorporation of bushings in manifold use two washers, P/N AN 122582 under each outer mounting lug (between fixture and lug or support) if PWA-8376 Holding Fixture is used.

FUEL MANIFOLD - REMOVAL/INSTALLATION

B. Installation

NOTE: Engines converted to smokeless burner configuration require use of new left and right fuel manifolds that must only be used in this new configuration even though old and new manifolds are physically interchangeable.

CAUTION: INSPECT BURNER PRESSURE AIR PASSAGE IN FUEL MANIFOLD INLET ADAPTER AND RIGHT FUEL MANIFOLD FOR EVIDENCE OF ANY RESTRICTION. ENSURE PASSAGE IS FREE AND CLEAR OF ANY RESIDUE. USE WIRE PROBE, AS REQUIRED, TO REMOVE CARBON DEPOSITS.

(1) Install fuel manifold retaining bolts (short bolts) through lugs on outer diameter of diffuser case.

NOTE: Bolt heads will be towards front of engine with flats toward diffuser case.

(2) Secure bolts to lugs with snaprings.

NOTE: ID of outer snapring is smaller than ID of inner snapring.

(3) Install fuel manifold retaining bolts (long bolts) up through brackets on inner diameter of diffuser case. Bolt heads will be toward front of engine with flats toward brackets.

NOTE: Engines incorporating diffuser case inner mount lug bushings must have bushings installed prior to retaining bolt installation. See Figure 401. Bushings should be inspected for wear per Section 72-0. Inspection/Check.

(4) Secure bolts to brackets with snaprings.

(5) Apply Fel-Pro C200 anti-galling compound to outer mounting lugs of right and left fuel manifold assemblies; then position assemblies on fuel manifold retaining bolts with nozzles facing to rear of engine and adapters in line with fuel pressurizing and dump valve mount pad in diffuser case.

CAUTION: MAKE CERTAIN GASKET IS PROPERLY CENTERED TO PREVENT EXTRUSION OF SEALS BETWEEN PRESSURIZING AND DUMP VALVE AND FUEL MANIFOLD ADAPTER FLANGE AT INSTALLATION OF DUMP VALVE.

(6) Install a gasket between adapter and diffuser case.

FUEL MANIFOLD - REMOVAL/INSTALLATION

(7) Insert PWA-8060 Locator through fuel inlet opening in diffuser case and secure to fuel manifold inlet adapters with screws.

NOTE: PWA-17721 Locator is used on engines incorporating laminated "V" type (chevron) gaskets between fuel manifold, fuel manifold inlet spacer, and fuel pressurizing and dump valve assembly.

(8) Coat adapter retaining bolts with Ease-Off 990 or Fel-Pro C200 anti-seize compound and insert them through diffuser case and into adapter. Tighten bolts to recommended torque and lockwire.

(9) Remove locator from diffuser case.

(10) Place fuel manifold locks (flanges up) over inner fuel manifold retaining bolts.

NOTE: Locks should be inspected for wear in accordance with Section 72-0, Inspection/Check.

(11) Install tabwashers over inner fuel manifold retaining bolts with single tab in lockring hole and tighten nuts fingertight.

NOTE: Bolts and nuts without tabwasher configuration must be lockwired.

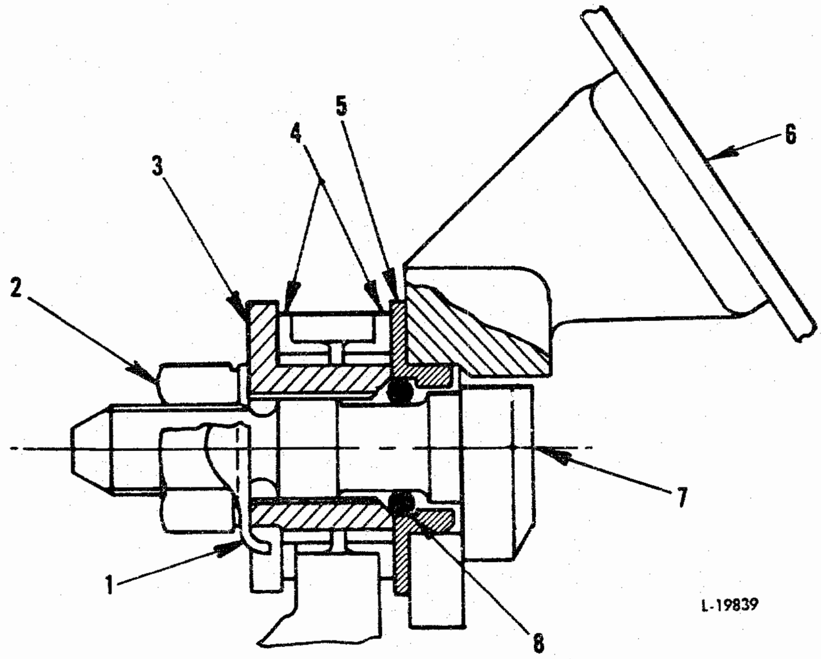
(12) Install combustion chamber positioning brackets on outer fuel manifold retaining bolts and then install tabwashers and nuts on outer fuel manifold retaining bolts. Tighten nuts fingertight. See Figures 402 and 403.

NOTE: On manifold assemblies containing flexible mounting brackets, install the two similar combustion chamber positioning brackets at the No. 4 and 5 chamber bolt locations in accordance with step (12). Install bushings and remaining combustion chamber positioning brackets on other manifold retaining bolts and then continue in step (12).

(13) Tighten all nuts (with exception of nuts securing No. 4 combustion chamber positioning bracket) to recommended torque. Secure nuts by bending tabwashers. PWA 30744 Pliers may be used to bend tabwashers.

NOTE: Inner diameter fuel manifold retaining nuts must be tightened first. After tightening inner diameter retaining nuts, but before bending tabwashers, check that axial clearance within stackup at fuel manifold ID mounts is within 0.001 to 0.006 inch. (Each cluster must exhibit some radial movement after 0.001-0.006 inch dimensions are established.) Length of lock (P/N 524325) may be changed by machining or grinding unflanged end to obtain desired stackup fit.

FUEL MANIFOLD - INSPECTION/CHECK

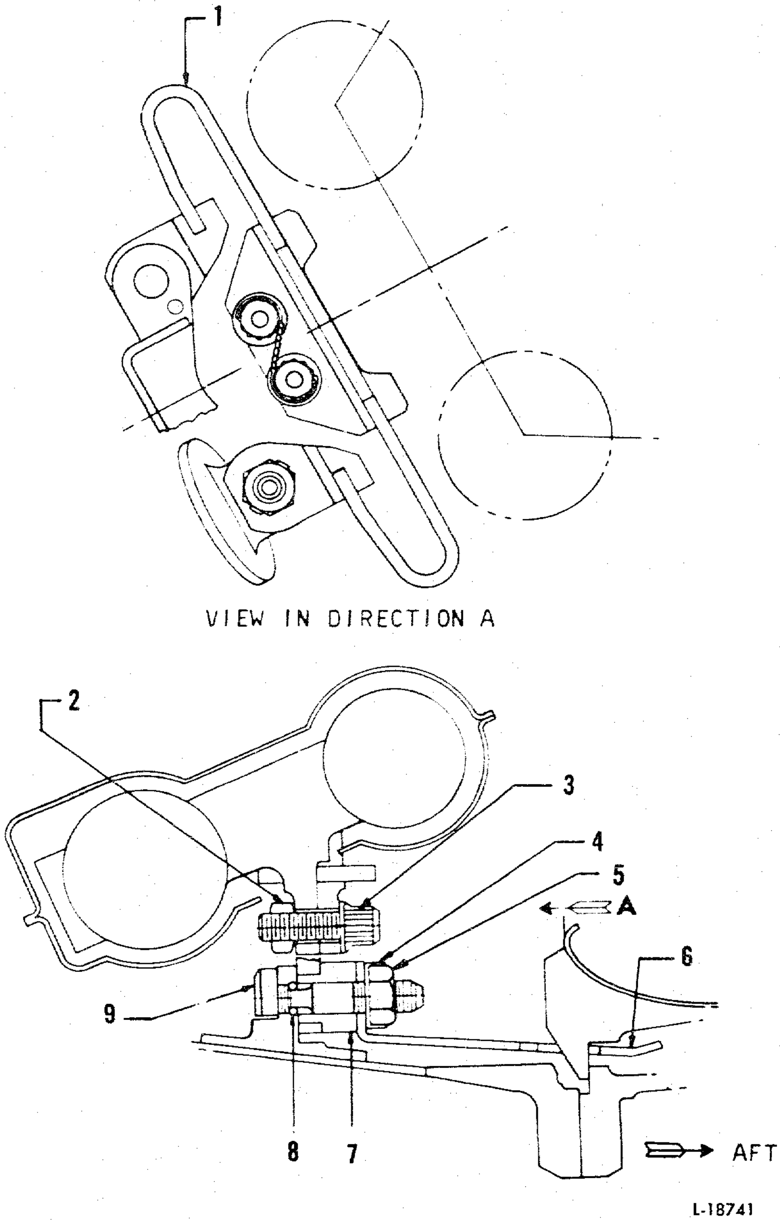


1. Tabwasher
2. Nut
3. Fuel Manifold Lock
4. Fuel Manifold Inner Mount Bushing
5. Diffuser Case Inner Mount Bushing
6. Diffuser Case Mounting Lug
7. Retaining Bolt
8. Snapring

Fuel Manifold Inner Diameter Mounting
(Engines Incorporating Mount Lug Bushings)

Figure 401

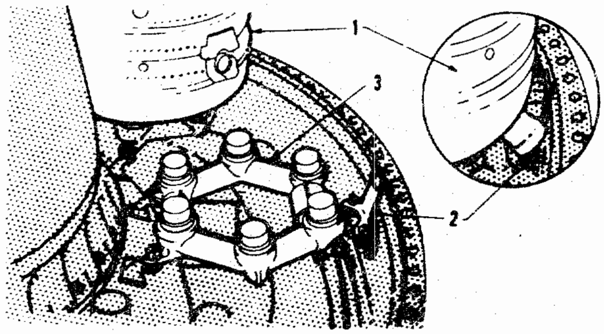
FUEL MANIFOLD - INSPECTION/CHECK



1. Bracket Assembly
2. Nut
3. Bolt
4. Tabwasher
5. Nut
6. Bracket
7. Bushing
8. Snapring
9. Bolt

Fuel Manifold Spring Mounting Configuration
(At Clusters No. 1, 2, 3, 6, 7, and 8 Only)
Figure 402

FUEL MANIFOLD - REMOVAL/INSTALLATION



1. Combustion Chamber

2. Combustion Chamber Positioning Bracket

3. Fuel Nozzle Cluster

Combustion Chamber Positioning Bracket
Figure 403

3. Numerical Tool List

PWA 8060 Locator

PWA 8376 Fixture

PWA 17591 Support

PWA 17721 Locator

PWA 17921 Fixture

PWA 30744 Pliers

FUEL MANIFOLD - ADJUSTMENT/TEST

1. Exhaust Gas Temperature Spread Test

If a condition of nozzle flow restriction or improper assembly of combustion chamber liners is suspected, perform the exhaust gas temperature spread test as indicated in Chapter 72-0, ENGINE - ADJUSTMENT/TEST.

NOTE: Exhaust gas temperature spread test need not be performed. (Optional.)

FUEL MANIFOLD - INSPECTION/CHECK

1. Fuel Manifold and Fuel Nozzle Internal Pressure check

NOTE: If manifold is acceptable after performing internal pressure check, complete clogged fuel nozzle check (Paragraph 2). If flow is satisfactory, perform inspection of fuel manifold with nozzles (Paragraph 3). If flow is not satisfactory, send manifold to overhaul.

A. Procedure

(1) Prepare all nozzles for pressure checking by making sure that all nozzles are clean in area adjacent to openings. Since pressure check clamps can force carbon into openings and clog them, it is important that these areas which are contacted by sealing caps be clean. See 73-6-1, CLEANING/PAINTING.

(2) Attach PWA 8281 Adapter to inlet pad of ruel manifold.

NOTE: Manifolds should be removed from engine for accomplishment of maintenance procedures. If manifold assembly is not removed from engine, it will be necessary to remove fuel pressurizing and dump valve prior to installing adapter on manifold inlet pad. If fuel manifold inlet adapter incorporates hardened sealing surfaces to accommodate laminated V Gaskets (chevron type), use PWA 17080, Fuel Manifold Pressure Test Adapter.

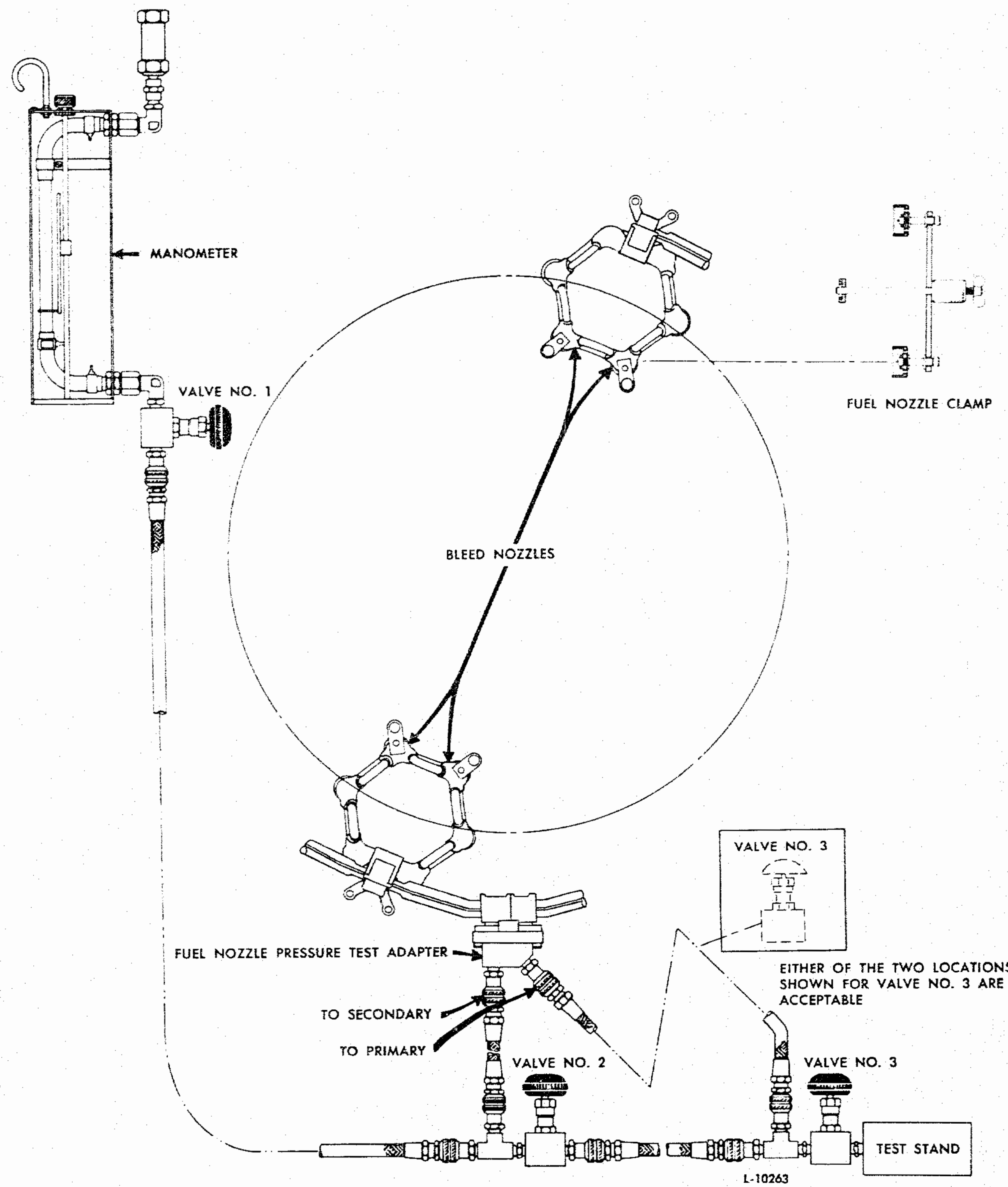
(3) Attach PWA 8299 Clamp, and PWA 31610 Seal (Delevan) or PWA 31611 Seal (Excello) on all nozzles.

(4) Set up PWA 7441 Burette & Valve Assembly so that midpoint of burette scale is approximately at top of fuel manifold; then attach quick disconnect connections to primary (small) and secondary (large) connectors on fuel manifold pressure test adapter installed on inlet pad of fuel manifold. See Figure 601.

(5) Attach burette valve inlet to outlet connection of test stand.

CAUTION: FLUID LEVEL IN MANOMETER AFTER SYSTEM IS BLED SHALL BE EQUAL TO HIGHEST POINT OF FUEL MANIFOLD.

(6) Open valves 1, 2, and 3. Turn on test fluid at low pressure, after providing suitable container to collect excess fluid; then bleed air out of primary and secondary lines of each cluster by loosening and tightening clamps, starting at six o'clock position.



Pressure Checking Fuel Manifold and Nozzles

Figure 601

(7) Shut off valve 2; then increase pressure to 600 psi and observe burette for five minutes. Leakage from primary to secondary as indicated by rise in fluid level shall not exceed 25cc. per five minute period for each bare manifold half. For manifolds containing nozzles, leakage in excess of three cc. per five minute period more than that indicated for same bare manifold half is cause for rejection.

(8) Close valve 1 and open valve 2. This will subject both primary and secondary to 600 psi. Inspect for external leakage.

(9) Disconnect quick disconnectors from adapter on fuel inlet pad of manifold and drain fluid into suitable container. While fluid is draining, remove nozzle clamps from top to bottom.

(10) Remove test adapter from inlet pad of adapter.

(11) Install manifold assembly, and/or pressurizing and dump valve, which was removed.

2. Clogged Fuel Nozzle Check

A. This procedure may be used as an optional check after it has been determined that exhaust gas temperature spread is unsatisfactory. The purpose is to isolate individual clogged fuel nozzles which must be replaced. When this check is to be used, proceed as follows:

(1) Slide combustion chamber outer front case rearward and determine that combustion chamber liners were properly installed.

(2) Remove eight combustion chambers and inspect engine for excessive bowing of nozzle guide vanes, and inspect other hot section parts for cracks, warpage and localized heat damage.

(3) If visual inspection is satisfactory and engine can be continued in service, clean fuel nozzles. Inspect nozzles for loose, burned or missing air caps, broken or missing tablocks, evidence of seal leakage, and clogged air gaps or holes. Mark or record unsatisfactory nozzles for replacement.

(4) Additional nozzles which must be replaced because of clogging and restriction of fuel flow can be determined by flow check.

(5) Remove pressurizing and dump valve. Install PWA 8281 Adapter to fuel manifolds.

NOTE: Use PWA 17080 Fuel Manifold Pressure Test Adapter, in place of PWA 8281 Fuel Manifold Pressure Test Adapter. The fuel manifold inlet adapter incorporates hardened sealing surfaces to accomodate laminated V Gaskets (chevron type).

FUEL MANIFOLD - INSPECTION/CHECK

(6) Install PWA 8299 Clamp, and PWA 31610 Seal (Delevan) or PWA 31611 Seal (Excello) on nozzles of seven clusters, leaving nozzles of one cluster open.

(7) Install PWA 17226 Cover (or PWA 8585 Cover) to open cluster to collect test fluid and provide suitable receptacle for drain.

(8) Attach fluid (special run Stoddard Solvent) inlet line to fuel manifold pressure test adapter primary connection and fluid suction (return) line from test stand to fitting on sump of PWA 17226 Cover (or PWA 8585 Cover).

(9) Supply fluid to primary manifold at pressure of 10 to 15 psig and observe individual nozzles. A uniform bulb or V shape spray pattern should be seen. If there is no flow, nozzle must be replaced. If flow pattern is not uniform or is excessively streaky, replace nozzle. Shut off test fluid.

(10) Check secondary nozzle orifice independently of primary nozzle orifice by repeating step (9) while supplying test fluid to secondary manifold. Shut off test fluid.

(11) After marking or recording unsatisfactory nozzles for replacement, install seals and clamps on nozzle cluster just tested and remove seals and clamp from another cluster.

(12) Repeat procedure from step (9) through (11) as necessary until all nozzles have been checked.

(13) Replace unsatisfactory nozzles; then after nozzles have been replaced perform manifold pressure check.

3. Inspection of the Fuel Manifold with Nozzles

A. If it is discovered through exhaust gas temperature spread and/or clogged fuel nozzle checks that manifold or nozzles are clogged, or that there is leakage past nozzle seals, manifold and/or nozzles must be replaced.

B. After repair, pressure check manifold and nozzles and recheck exhaust gas temperature spread. If any of these checks are not satisfactory, it is an indication that a malfunction still exists. Repeat any necessary repair procedures until all checks indicate satisfactory performance.

C. During normal periodic visual inspection, carbon build-up on nozzles must be removed. Refer to 73-6-1, CLEANING/PAINTING. Inspect fuel nozzles for following conditions:

(1) Broken or missing tablocks. Install new tablock.

FUEL MANIFOLD - INSPECTION/CHECK

(2) Evidence of seal leakage. If any of following conditions occur, replace seal.

(a) Localized engine damage due to heat.

(b) Excessive carbon formation on any one nozzle in relation to other nozzles.

(3) Clogged cooling air gaps or holes. If they are clogged they must be cleaned.

D. Inspect fuel manifold nozzle body. If no sleeve is installed on nozzle body and diameter of each nozzle body is not less than 1.187 inches at any point, fuel manifold is acceptable. If flame plated sleeve is installed on nozzled body, following conditions apply. Replace sleeve if OD measures less than 1.213 inches where worn. If wear limit is met and 85 percent or more of original area of hardfacing on sleeve remains, fuel manifold is acceptable.

E. Inspect bushings of inner mounting lugs. Replace bushings where flanges measure less than 0.032 inch thick at any time. Reject fuel manifolds to overhaul for replacement of sleeves and/or bushings, and install new fuel manifold per Section 73-5-1, Removal/Installation.

F. Inspect fuel manifold retaining bolts, bushings, locks, and nuts for thread damage and/or wear. Replace as necessary.

G. Inspect fuel manifold for loose heatshields. No looseness is allowed. If looseness is found, replace fuel manifold heatshield and all insulation material. Refer to Section 73-5-1, Fuel Manifold Repair of Accessory Component Overhaul Manual, PN 411569.

4. Numerical Tool List

PWA 7441 Burette

PWA 8281 Adapter

PWA 8299 Clamp

PWA 8299-51 Seal Set
(Superseded by PWA 31610)

PWA 8299-52 Seal Set
(Superseded by PWA 31611)

PWA 8585 Cover

PWA 17080 Adapter

PWA 17226 Cover

PWA 31610 Seal
(Supersedes PWA 8299-51)

PWA 31611 Seal
(Supersedes PWA 8299-52)

FUEL NOZZLES - DESCRIPTION AND OPERATION

1. Description

See Figures 1, 2, 3, and 4.

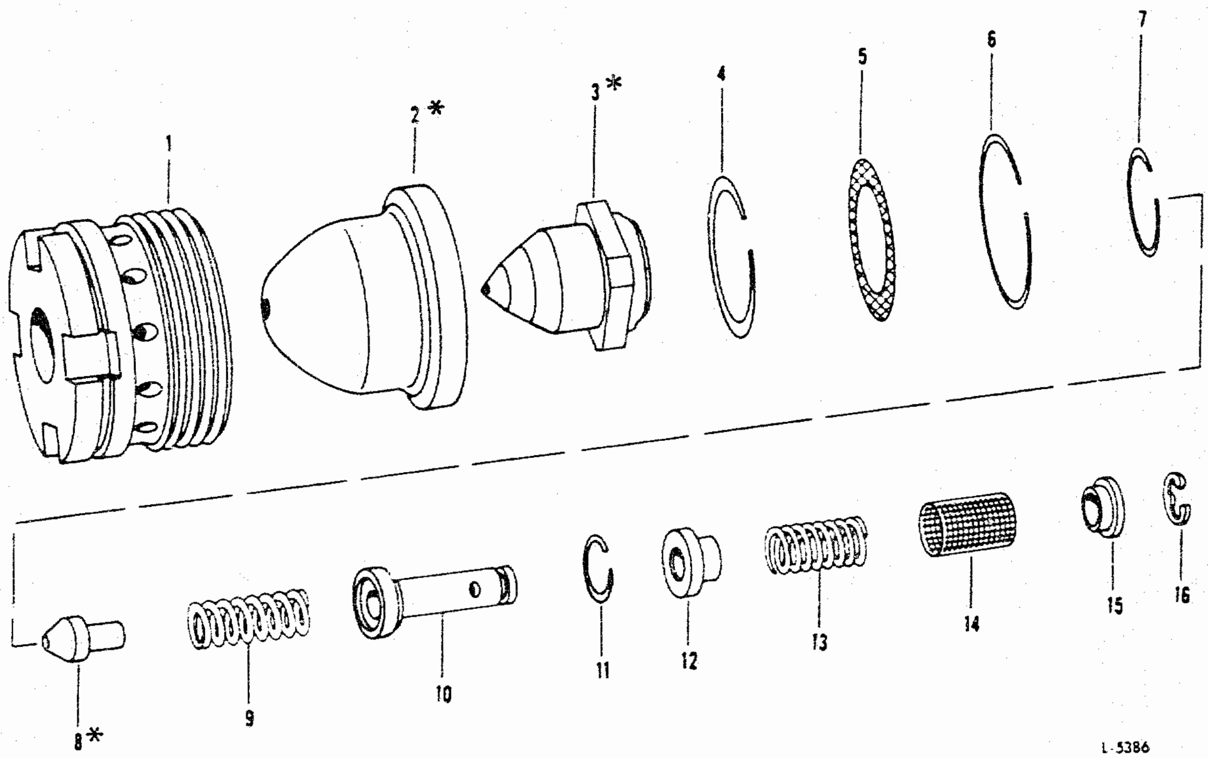
Twenty-four nozzles are mounted in each manifold, making a total of forty-eight per engine. There are two fuel outlets in each nozzle, a small center hole and a ring around the center hole. Primary fuel from the outer manifold tube is sprayed out of the center hole. The ring sprays secondary fuel. This is done so that the small fuel flow that is used in idling will be broken up into a fine spray by being forced through a small outlet. The relatively larger outlet formed by the ring will generate a fine spray on the large flow of secondary fuel. Two screens are mounted in the rear of each nozzle, one for primary fuel and the other for secondary fuel. The primary screen is a small cylindrical type, while the secondary is a flat round type. Transfer of fuel from the tubes in the nozzle clusters is done by the nozzle body which contains internal passages that connect the nozzle center passage to the outer fuel tube and the nozzle outer passage to the inner fuel tube. Fuel nozzle seals, held under each nozzle, prevent leakage between passages and leakage to exterior. Each nozzle is held in place in the cluster by a threaded nozzle cap and a tabwasher. There are holes around the nozzle cap wall to admit air for cooling and to aid in fuel vaporization.

2. Operation

Fuel is supplied to the primary and secondary orifices through separate manifold paths. The nozzle may be operated with spray from the primary orifice or with spray from both primary and secondary orifices as is the case at higher fuel flow. When both orifices are delivering fuel their output is blended into a single spray.

The dual orifice nozzles are designed to discharge a predetermined amount of fuel when specified pressure heads are maintained across the primary and secondary stages. Extremely accurate calibration of each fuel nozzle minimizes flow variations between nozzles. Since the nozzle acts both as an atomizing and as a metering device, each nozzle must deliver a uniform spray pattern free from streaks and with an angle of spray which is held within close tolerances.

FUEL NOZZLES - DESCRIPTION AND OPERATION

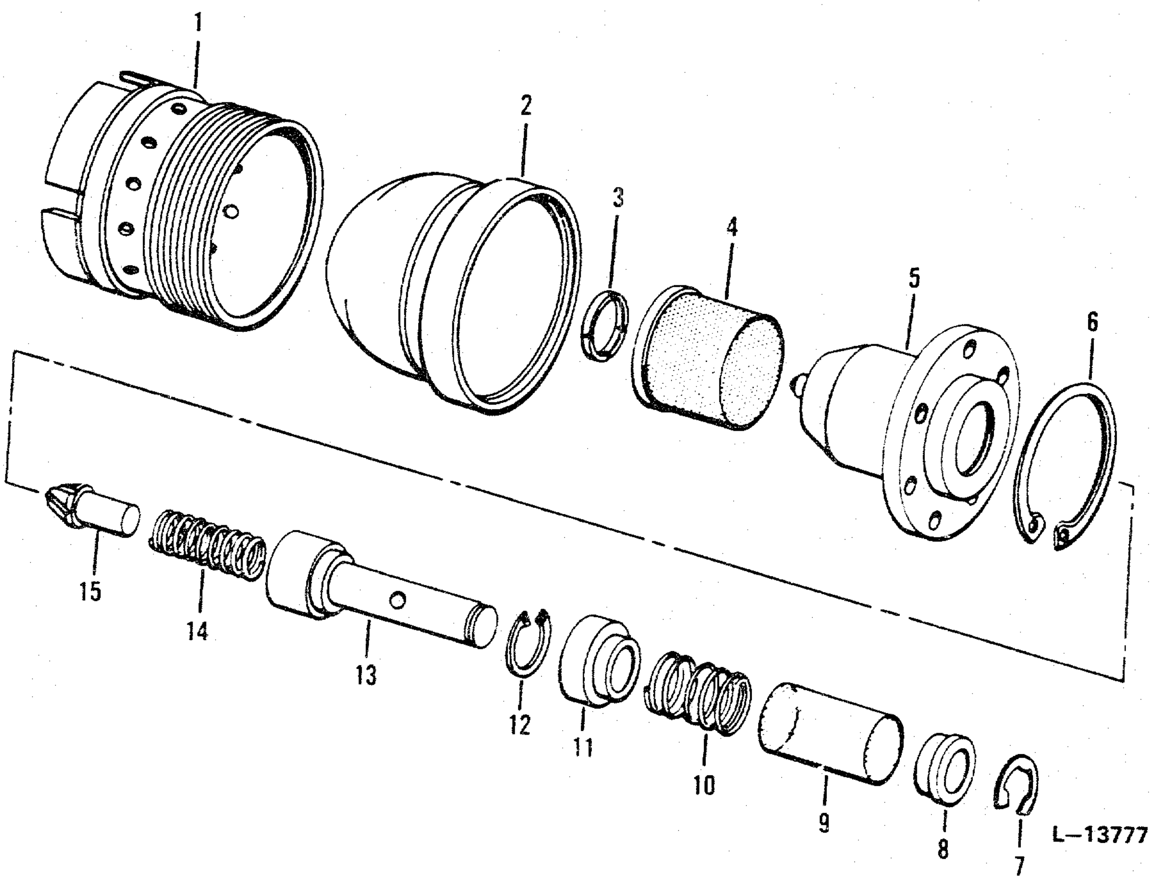


1. Retaining Nut
2. Nozzle Body*
3. Insert*
4. Insert Snapring
5. Secondary Strainer
6. Secondary Strainer Outer Snapring
7. Secondary Strainer Inner Snapring
8. Primary Plug*
9. Spring
10. Spring Seat
11. Spring Seat Snapring
12. Lower Primary Strainer Ferrule
13. Spring
14. Primary Strainer
15. Upper Primary Strainer Ferrule
16. Primary Strainer Snapring

*Matched Metering Set Details

Non Aerated Fuel Nozzle (PN 260366, 708074)
Figure 1

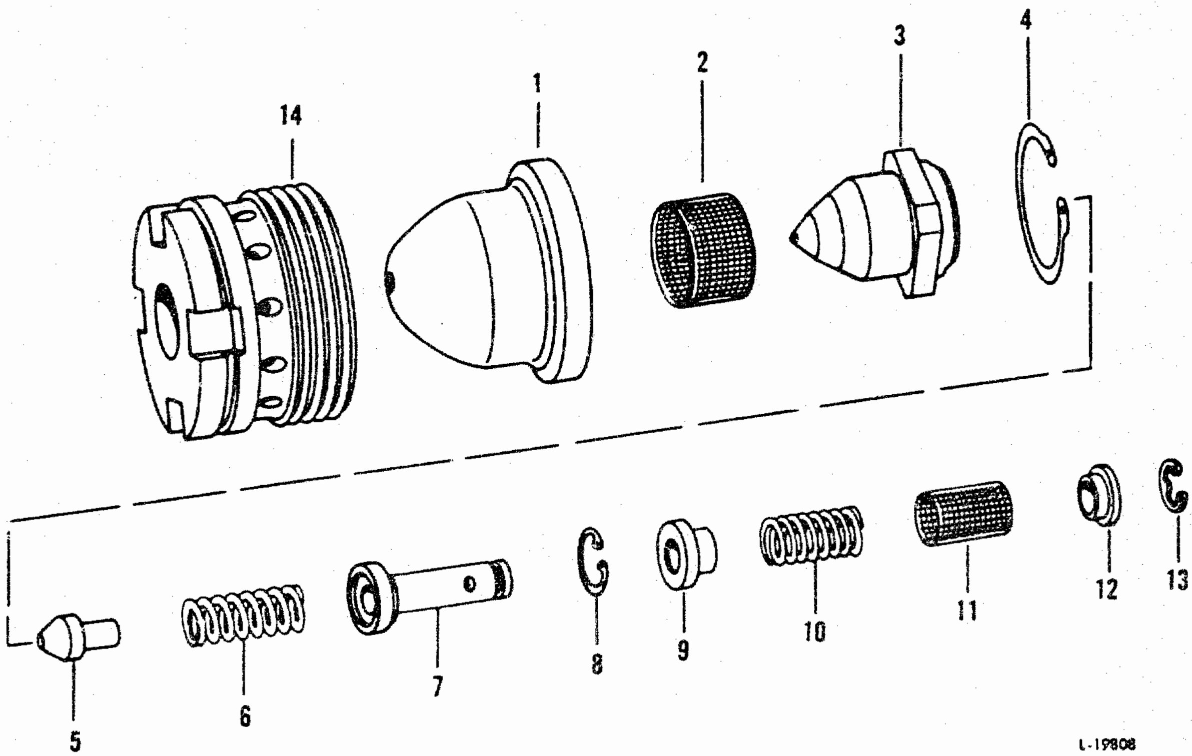
FUEL NOZZLES - DESCRIPTION AND OPERATION



1. Retaining Nut
2. Nozzle Body
3. Metering Ring
4. Secondary Strainer
5. Insert
6. Insert Snapring
7. Primary Strainer Snapring
8. Upper Primary Strainer Ferrule
9. Primary Strainer
10. Spring
11. Lower Primary Strainer Ferrule
12. Spring Seat Snapring
13. Spring Seat
14. Spring
15. Primary Plug

Non Aerated Fuel Nozzle (PN 481615)
Figure 2

FUEL NOZZLES - DESCRIPTION AND OPERATION

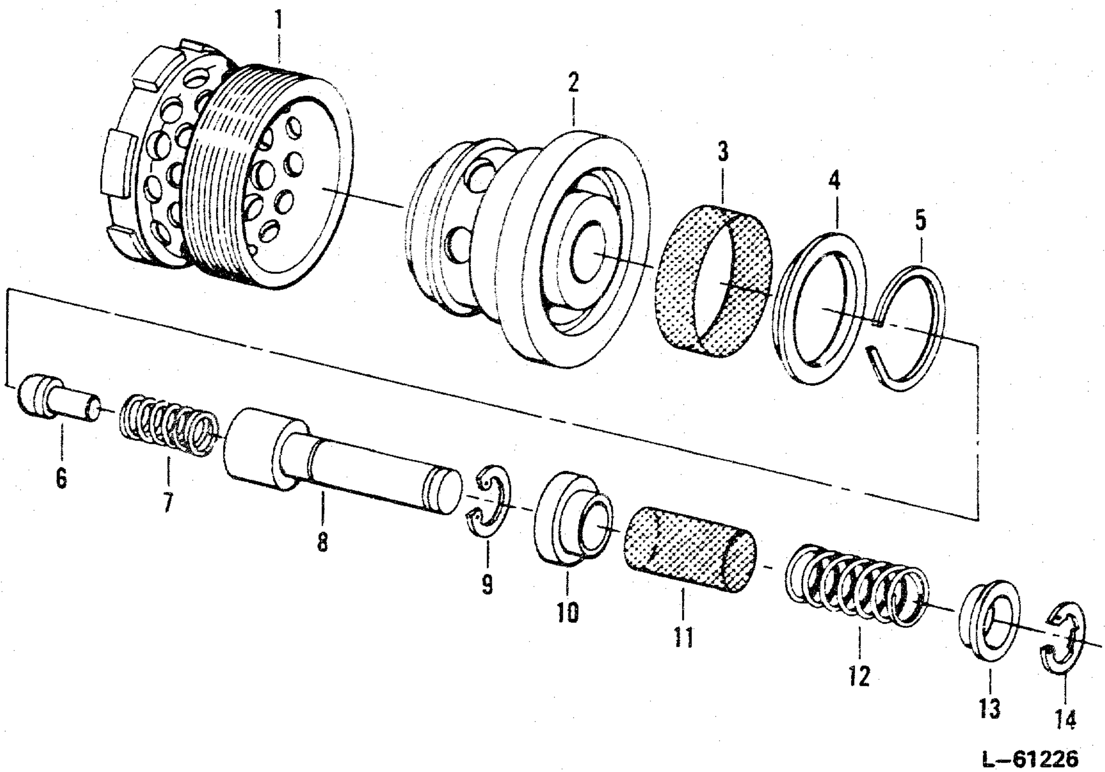


1. Nozzle Body*
2. Secondary Strainer
3. Insert*
4. Insert Snapring
5. Primary Plug*
6. Spring
7. Spring Seat
8. Spring Seat Snapring
9. Lower Primary Ferrule
10. Spring (Primary)
11. Primary Strainer
12. Upper Primary Ferrule
13. Primary Strainer Snapring
14. Retaining Nut

*Matched Metering Set - Install In Sets Only.

Non Aerated Fuel Nozzle (PN 518125, 696093)
Figure 3

FUEL NOZZLES - DESCRIPTION AND OPERATION



1. Retaining Nut
2. Fuel And Air Swirler
3. Secondary Strainer
4. Secondary Strainer Ferrule
5. Secondary Strainer Snapring
6. Primary Insert
7. Spring
8. Primary Strainer Body
9. Snapring - Primary Strainer Body
10. Lower Primary Strainer Ferrule
11. Primary Strainer
12. Spring
13. Upper Primary Strainer Ferrule
14. Primary Strainer Snapring

Aerated Fuel Nozzle (PN 748822)
Figure 4

FUEL NOZZLE - REMOVAL/INSTALLATION

1. Removal/Installation of Fuel Nozzles

NOTE: Refer to Chapter 72-0, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of fuel nozzles.

A. Removal

NOTE: To remove fuel nozzle, combustion section outer case must be slid rearward and combustion chambers removed from engine. Refer to Chapter 72, ENGINE for detailed combustion chamber removal instructions.

(1) Using PWA 8487 Plier, straighten retaining tabwasher.

(2) Using PWA 8486 Starting Wrench and then PWA 17791 Wrench (for non aerated fuel nozzles) or PWA 31567 Wrench (for aerated fuel nozzles), remove fuel nozzle from manifold.

(3) Remove remaining nozzles in same manner.

B. Installation

CAUTION: MAKE CERTAIN MIXTURE IS THICK ENOUGH TO PREVENT ANY CONTAMINATION OF FUEL NOZZLE SCREEN AND APPLY IT TO THREADS SPARINGLY.

(1) Using small brush, apply mixture of molybdenum disulphide powder, Molykote Type Z or equivalent, and compounded oil, AMS 3065, to nozzle threads.

(2) Use only overhauled and/or calibrated fuel nozzles. If nozzles have been classified, install twenty-four Class A or twenty-four Class B nozzles in each manifold assembly.

NOTE: Classification of fuel nozzles is optional. Only fuel nozzles or fuel manifold assemblies of same classification (either A or B) should be installed on any one engine.

(3) Place new seal and tabwasher on fuel nozzle body.

(4) Using PWA 17791 Wrench (for non aerated fuel nozzles) or PWA 31567 Wrench (for aerated fuel nozzles), install nozzle in manifold. Tight nozzle from 300 - 500 pound-inches.

(5) Bend tab of tabwasher into slot in fuel manifold.

(6) Install remaining nozzles in same manner.

FUEL NOZZLE - INSPECTION/CHECK

1. Inspection of Fuel Nozzles (and Manifold)

Deterioration of the fuel nozzles may be indicated by carbon restriction of the nozzle secondary flow passages. This fuel nozzle flow restriction generally upsets the normal tailpipe temperatures, thus reducing the life of "hot section" parts. Testing and inspection of the fuel nozzles together with their associate part, the manifold, is discussed in Section 73-5-1.

FUEL NOZZLE - CLEANING/PAINTING

1. Cleaning of Fuel Nozzles (in Manifold)

A. Procedure

(1) Provide a reasonably clean work area for the airplane or, if possible, a shelter over the engine to prevent wind from blowing dirt and dust into the engine if the work is to be performed out of doors.

(2) Remove the primary and secondary tap plugs on the fuel pressurizing and dump valve and attach a source of filtered compressed air of sufficient volume to eliminate the possibility of carbon or dirt entering the nozzles during the cleaning operation. Remove the overboard drainline and cap the fitting in the dump valve to prevent the compressed air from escaping.

WARNING: USE SAFETY GOGGLES OR OTHER ADEQUATE PROTECTION TO PROTECT EYES FROM FLYING DUST AND CARBON PARTICLES.

(3) While the air is passing through the primary and secondary orifices, remove any carbon formation on the rear face of the nozzle, using a stiff bristle or soft non-ferrous metal fine wire brush.

CAUTION: CARE MUST BE EXERCISED TO MAKE SURE THAT THE METAL BRUSH DOES NOT COME IN CONTACT WITH THE NOZZLE ORIFICES, AND THAT THE NOZZLE ORIFICES ARE NOT CLOGGED DURING THE CLEANING.

(4) Remove all carbon formations from the air gaps and air holes using wood (orange sticks) or soft non-ferrous metal picks.

NOTE: It is not necessary to remove stains. However, the area around the orifice shall be clean enough to permit proper sealing of the clamp used during the pressure check following nozzle replacement.

(5) While the air is passing through the system, carefully clean the manifold cluster and diffuser areas to prevent the possibility of carbon getting into the manifold during nozzle replacement.

CAUTION: AS NOZZLES ARE TO BE REPLACED ONE AT A TIME, CLEAN COVERS SHALL BE PROVIDED AND INSTALLED OVER ALL CLUSTERS NOT BEING WORKED ON.

FUEL DE-ICING FILTER ASSEMBLY - DESCRIPTION AND OPERATION

1. Description

The fuel de-icing filter assembly (optional equipment) consists of a 40 micron filter element encased in a cylindrical housing which is mounted just aft of the fuel pump. This housing also contains a by-pass valve and an electrical pressure drop warning switch.

2. Operation

Fuel flows through the filter at all times. When icing conditions exist, ice will collect on the surface of the filter element causing the pressure drop in the housing to increase. When the pressure drop reaches 4.5 psi, the pressure drop warning switch will close sending an electrical signal to the cockpit. If the filter has become clogged, the filter by-pass valve will open permitting the fuel to flow.

FUEL DE-ICING FILTER - REMOVAL/INSTALLATION

1. General

A. Disconnect or remove all necessary tubes to permit fuel de-icing filter removal. See Chapter 73-0, REMOVAL/INSTALLATION for tube removal and installation instructions.

NOTE: Refer to Chapter 72-0, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of the fuel de-icing filter or filter element.

B. Draining the Fuel De-Icing Filter

(1) Provide a suitable container of five gallon minimum capacity.

(2) Drain the fuel de-icing filter by removing the drain plug.

(3) Install a new "O" ring seal on the drain plug. Tighten until the plug is seated, torque to 50 pound-inches, and lockwire.

2. Removal/Installation of the Fuel De-Icing Filter

A. Removal

(1) Disconnect the tube nut securing the fuel outlet heater-to-fuel de-icing filter tube to the elbow on the filter.

(2) Disconnect the tube nut securing the fuel de-icing filter-to-fuel pump tube to the connector on the filter.

(3) Disconnect the electrical lead (airframe).

(4) Remove the bolt, washer, nut, and spacer securing the filter assembly link to the bracket on the lower left location of the front compressor case rear flange.

(5) Remove the bolts and nuts securing the lugs of the filter assembly to the intermediate case mount rings. Remove the filter assembly.

NOTE: If the oil adapter has been removed, the bolts mentioned in step 5 will have already been removed.

B. Installation

(1) Position the lugs of the fuel filter so that they line-up with and are inside of the legs of the oil adapter; then install the two bolts, from the outside, through the intermediate case mount rings, through the legs of the oil adapter, and through the lugs of the fuel filter. Secure them on the inside with the nuts. Tighten the nuts to the recommended torque.

FUEL DE-ICING FILTER - REMOVAL/INSTALLATION

(2) Insert the spacer in the filter assembly link; then install the bolt and washer (bolt head forward) through the bracket and the link and secure it with the nut. Tighten the nut to the recommended torque.

(3) Coat the new seal with engine oil and install the seal on the end of the fuel de-icing filter-to-fuel pump tube. Install the retainer on the end of the tube. Position the tube to the elbow on the filter and secure with the tube nut. Tighten the nut to the recommended torque and lockwire.

(4) Coat the new seal with engine oil and install the seal on the end of the fuel outlet heater-to-fuel de-icing filter tube. Install the retainer on the end of the tube. Position the tube to the elbow on the filter and secure with the tube nut. Tighten the nut to the recommended torque and lockwire.

(5) Connect the electrical lead (airframe).

3. Removal/Installation of the Fuel De-Icing Filter Element

A. Removal

(1) Loosen the retainer bolt and remove the filter housing.

(2) Remove and discard the filter element.

(3) Discard the "O" ring seal between the cover and housing.

B. Installation

(1) Install a new "O" ring seal between the cover and housing.

(2) Insert a new filter element in the housing.

(3) Position and install the filter housing. Torque the retainer bolt 250 to 300 pound-inches and lockwire.

FUEL DE-ICING FILTER-INSPECTION/CHECK

1. Presence of Water Check

A. Procedure

(1) Provide a suitable container of five gallon minimum capacity.

(2) Remove the drain plug and permit accumulated water to drain.

(3) Install a new "O" ring seal on the drain plug. Tighten the plug until it is seated, torque to 50 pound-inches, and lockwire.

DIFFERENTIAL FLUID PRESSURE SWITCH - DESCRIPTION AND OPERATION

1. Description

The differential fluid pressure switch mounted on the fuel de-icing filter assembly measures the filter inlet and filter outlet fuel pressure difference.

2. Operation

When icing conditions exist within the fuel de-icing filter, ice collects on the surface of the filter element causing a pressure drop in the housing. Upon reaching a pressure differential across the filter of 4.5 psi, the differential fluid pressure switch activates a warning light in the cockpit.

DIFFERENTIAL FLUID PRESSURE SWITCH - REMOVAL/INSTALLATION

1. Removal/Installation of Differential Fluid Pressure Switch

A. Removal

(1) Disconnect the electrical lead (airframe).

(2) Remove the four bolts and washers securing the differential fluid pressure switch to the fuel de-icing filter cover and remove the switch.

B. Installation

(1) Install the differential fluid pressure switch and secure with four bolts and washers. Tighten cap screws to torque of 15 to 18 pound inches and lockwire.

(2) Connect the electrical lead (airframe).

FUEL DE-ICING HEATER - DESCRIPTION AND OPERATION

1. Description

The fuel de-icing heater (optional equipment) is located between the boost and main stages of the engine-driven fuel pump. The function of the heater is to protect the engine fuel system from ice. The fuel de-icing heater uses high compressor discharge air as a source of heat. All of the engine fuel flow passes through the fuel de-icing heater at all times. The fuel is heated, however, only when an air inlet valve is opened, allowing high compressor discharge air to flow through the air side of the heater.

2. Operation

Operation of the fuel de-icing heater is controlled manually. A pressure switch within the fuel de-icing filter activates at 4.5 psi pressure differential across the filter and turns on a warning light. A fuel heat switch can be actuated, which will open the fuel heater air valve. This allows engine bleed air to pass through the tubes of the heater, thus warming the fuel which is baffled around these tubes. The resulting warm fuel will melt any ice formation within the filter and the warning light will go out as the pressure drop across the filter is decreased.

FUEL DE-ICING HEATER - REMOVAL/INSTALLATION

1. General

A. Disconnect or remove all necessary tubes to permit fuel de-icing heater removal. See Chapter 73-0, REMOVAL/INSTALLATION for tube removal and installation instructions.

NOTE: Tag or note the location of the brackets to assure their installation in the same position.

2. Removal/Installation of the Fuel De-Icing Heater

NOTE: Refer to Chapter 72-0, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of the fuel de-icing heater.

A. Removal

(1) Disconnect the tube nut which secures the fuel outlet heater to filter tube to the fuel de-icing heater.

(2) Disconnect the tube nut which secures the fuel pump-to-fuel de-icing heater inlet tube to the fuel de-icing heater.

(3) Remove the bolts and nuts securing the fuel de-icing air valve to the pad at the top of the fuel de-icing heater.

(4) Remove the bolt, nut, and spacer securing the fuel heater link to the bracket on the front compressor rear case rear flange.

(5) Remove the bolts, nuts, washers, and spacers securing the fuel heater bracket to the brackets on the front compressor rear case middle and rear flanges. Remove the heater.

B. Installation

(1) Position the fuel de-icing heater and bracket to the brackets on the front compressor rear case middle and rear flange. Install the spacers through the brackets; then install the bolts (heads facing forward) through the spacers. Install the washers and nuts; then tighten them to the recommended torque.

(2) Install the spacer in the link and the bracket on the front compressor rear case rear flange; then install the bolt (head to the front) through the link and bracket. Secure it with the nut and tighten the nut to the recommended torque.

(3) Install a new gasket between the fuel de-icing air valve and the fuel de-icing heater pad. Secure the heater to the valve with the bolts and nuts. Tighten the nuts to the recommended torque.

FUEL DE-ICING HEATER - REMOVAL/INSTALLATION

(4) Coat the new seal with engine oil and install the seal on the end of the fuel pump-to-fuel de-icing filter inlet tube. Install the retainer on the end of the tube. Position the tube to the elbow on the heater and secure with the tube nut. Tighten the nut to the recommended torque and lockwire.

(5) Coat a new seal with engine oil and install the seal on the fuel outlet heater-to-filter tube. Install the retainer on the end of the tube. Position the tube to the elbow on the heater and secure with the tube nut. Tighten the nut to the recommended torque and lockwire.

LIST OF EFFECTIVE PAGES

Please insert the revised pages into this manual and delete obsoleted pages in accordance with the following List of Effective Pages. Revised pages are indicated by the letter "R", added pages by the letter "A", and deleted pages by the letter "D". Superseded pages shall be removed and destroyed.

The List of Effective Pages records not only each page of subject revision but also each previously issued page which is still current. Blank pages and pages which are no longer current do not appear on this list. If there is any question about the currency of the recipient's copy, it is recommended that each page of the manual be checked off against this List of Effective Pages. Any page which does not check out with this list, either by number or by date, shall be discarded.

CHAPTER/ SECTION		PAGE	DATE
Tab Separator - Ignition			
List of Effective Pages - Ignition			
	R/	A/B	Dec 15/86
Table of Contents - Ignition			
74		1/2	Jul 1/85
74-0		1	Jun 1/65
		2	Aug 1/62
		3	Jun 1/65
		4	Jun 1/65
		5	Dec 1/67
		6	Jun 1/65
		7	Jun 1/65
		8	Dec 1/67
		9	Dec 1/67
		10	Jul 1/85
		11	Jul 1/85
		12	Jul 1/85
		13	Jul 1/85
		14	Jul 1/85
		15/16	Jul 1/85
		101/102	Dec 15/77
		201	Dec 15/63
		202	Jun 1/65
74-1-0		1	Jun 1/65
		2	Jun 1/65
		201	Jun 15/77
		202	Dec 1/67
		203	Dec 1/67
		204	Dec 1/67
		205	Dec 1/67
		601/602	Jan 15/72
		701/702	Jan 15/72
74-2-1		1	Jun 1/65
		201	Dec 15/63
74-3-1		1/2	Jul 1/85
		201	Dec 1/67
		202	Jul 1/63
74-4-1		1/2	Jul 1/85
		201	Jul 1/85
		202	Jul 1/85
		203	Jul 1/85
		204	Jul 1/85
		205/206	Jul 1/85
		601	Jul 1/85
		602	Jul 1/85
		701/702	Jul 1/85
74-5-1		1	Aug 1/62
		201	Dec 15/63
74-6-1		1/2	Jul 1/85
		401/402	Jul 1/85
		501/502	Jul 1/85
		601	Jul 1/85
		602	Jul 1/85
	R/	603	Dec 15/86
		604	Jul 1/85
		605/606	Jul 1/85
		701/702	Jul 1/85

TABLE OF CONTENTS

IGNITION SYSTEM - DESCRIPTION AND OPERATION

1. General

The ignition system is electrically controlled from the flight compartment and therefore includes equipment which is provided by the airframe manufacturer. Equipment discussed in this chapter includes only that portion of the ignition system which is supplied by Pratt & Whitney Aircraft.

2. Theory of Operation

A. The ignition system designed for installation on the JT3D-1 and D-3 engines as installed on Douglas aircraft includes one intermittent duty exciter, one continuous duty exciter, one intermediate voltage lead, and two high tension leads. It is designed to fire two igniters during ground starts by means of the 20 joule intermittent duty exciter, or one igniter during flight by means of the four joule continuous duty exciter. The following description covers the operation of the complete system. (See Wiring Schematic, Figure 1).

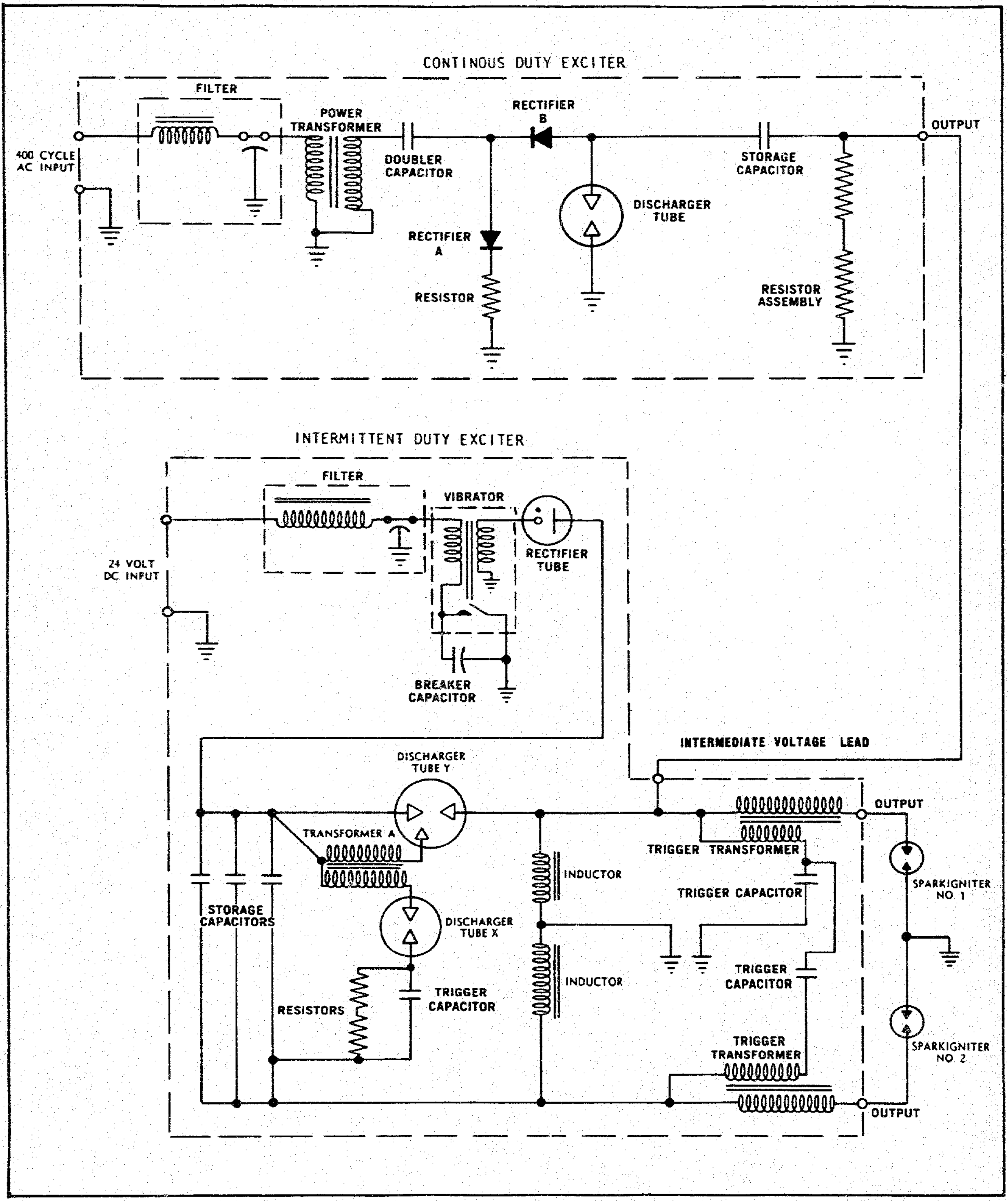
(1) When intermittent operation is to be employed, DC power is supplied to the input of the intermittent duty exciter from the 24-volt aircraft electrical system.

(a) It is first passed through a radio noise filter to prevent high frequency feedback. From the filter, input voltage is fed to the primary of the transformer in the vibrator, which is an integral part of the vibrator assembly. From the primary a current thus flows through a pair of contacts, normally closed, to ground. A capacitor is connected across these contacts to damp excessive arcing.

(b) With the contacts closed, the flow of current through the coil produces a magnetic field. The force exerted by this field pulls the armature free from the permanent magnet above it. Rapid acceleration builds up kinetic energy in the armature for a brief period before it strikes the contact spring. This opens the contact points quickly, the flow of current stops, and the magnetic field collapses. The armature is returned by the tension of the contact spring, and is positively held in its original position by the permanent magnet. The spring having meanwhile closed the contacts, the vibrating cycle recommences.

(c) Each collapse of the magnetic field induces a high voltage in the secondary of the transformer. This produces successive pulses flowing through the gas charged rectifier, which limits the flow to a single direction, into the storage capacitors, which thus assume a greater and greater charge, at a constantly increasing voltage.

IGNITION SYSTEM - DESCRIPTION AND OPERATION



Wiring Schematic, Intermittent and Continuous Duty System

Figure 1

IGNITION SYSTEM - DESCRIPTION AND OPERATION

(d) When this intermediate voltage reaches the predetermined level for which Discharger Tube X has been calibrated, this tube breaks down. A small portion of the accumulated charge, flowing through the primary of Transformer A, induces a high voltage in the secondary. This voltage triggers the three-point, discriminating Discharge Tube Y, which breaks down and permits a surge of current to flow from the storage capacitors through the primary of the trigger transformers into the trigger capacitors. The very high voltage thus induced in the secondary of the trigger transformers is sufficient to ionize the gaps at the igniters, producing a trigger spark.

(e) The remainder of the energy on the storage capacitors is immediately discharged, following a path through the secondary of the trigger transformer and the high tension lead to the left hand igniter, through ground to the right hand igniter, and back through the other high tension lead and trigger transformer secondary to the storage capacitors.

(f) The inductance in the inductors is high enough so that the current shunted through them is not significant, but after completion of the spark cycle they provide a return path to bleed off any residual charge on the trigger capacitors.

(g) If one igniter is shorted, the operation is the same, producing only one spark.

(h) If the circuit to one igniter is open, the operation is the same, producing only one spark. The path from the operating igniter returns through ground and the inductor on the opposite side of the exciter circuit to the storage capacitors.

(2) When continuous operation is to be employed, power is supplied to the input of the continuous duty exciter from the 115-volt, 400 cycle AC source in the aircraft.

(a) It is first led through a filter which serves to block conducted noise voltage from feeding back into the aircraft electrical system. From the filter the circuit is completed through the primary of the power transformer to ground.

(b) In the secondary of the power transformer an alternating voltage is generated at a level of approximately 1500 volts. During the first half cycle this follows a circuit through the doubler capacitor and Rectifier A to ground, leaving the capacitor charged. During the second half cycle, when the polarity reverses, this circuit is blocked by Rectifier A; the flow of this pulse is then through ground and the resistors to the storage capacitor, through Rectifier B and the doubler capacitor back to the power transformer.

IGNITION SYSTEM - DESCRIPTION AND OPERATION

(c) With each pulse the storage capacitor thus assumes a greater and greater charge, which by virtue of the action of the doubler capacitor approaches a voltage approximately twice that generated in the power transformer. When this voltage reaches the predetermined level for which the spark gap in the discharger tube has been calibrated, this gap breaks down, and the accumulated charge on the storage capacitor reaches the output terminal of this exciter.

(d) From the output terminal it is carried to the intermittent duty exciter by the intermediate voltage lead. Being prevented from reaching the storage capacitors in this unit by the discriminating Discharger Tube Y, a portion of the charge flows through the primary of Trigger Transformer No. 1 into the associated trigger capacitor.

(e) This surge of current induces a very high voltage in the secondary of the trigger transformer, sufficient to ionize the gap at the left hand igniter. The remainder of the charge is immediately dissipated as a spark at the igniter, the return circuit being completed through ground to the continuous duty exciter.

(f) The inductor in the intermittent duty exciter serves to bleed off any residual charge on the trigger capacitor between spark cycles.

B. The ignition system designed for installation on the JT3D-1 and JT3D-3 engines, as installed on Boeing aircraft, and the system used on the JT3D-1-MC6 QANTAS and JT3D-1-MC7 engines, includes two 20-joule, intermittent duty ignition exciters, two high tension leads, and two input leads. Each exciter is connected directly to an igniter. The following description covers the operation on one side of this sytem. (See Wiring Schematics, Figures 2 and 3).

(1) The 24-volt DC power is supplied to the input of the exciter, and follows the same operational sequence described in paragraph 2A (1)(a), (b), and (c).

(2) The action of the discharge circuit is as follows:

(a) In Exciter Part No. 40355, when the intermediate voltage reaches the predetermined level for which the sealed discharger tube has been calibrated, the gap breaks down. A portion of the accumulated charge flows through the primary of the high tension triggering transformer, and into the trigger capacitor connected in series with it. This surge of current induces a very high voltage in the secondary of the transformer, sufficient to ionize the gap at the igniter, and produce a trigger spark. The storage capacitors immediately discharge the remainder of their accumulated energy through the igniter gap, together with the charge from the trigger capacitor. This results in a capacitive spark of very high energy.

IGNITION SYSTEM - DESCRIPTION AND OPERATION

(b) In Exciter Part No. 41468, when the intermediate voltage reaches the predetermined level for which the spark gap in Discharger Tube "A" (the control tube) has been calibrated, this gap breaks down, allowing a portion of the accumulated charge to flow through the primary of the high tension triggering transformer and the trigger capacitor connected in series with it. This surge of current induces a very high voltage in the secondary of the triggering transformer, sufficient to ionize the gap in Discharger Tube "B" and the gap at the igniter. The storage capacitors immediately discharge the remainder of their accumulated energy through the igniter, resulting in a capacitive spark of very high energy.

(3) The bleeder resistor is provided to dissipate any residual charge on the trigger capacitor between the completion of one discharge at the igniter and the succession of the next cycle.

(4) The spark rate will vary, depending on the value of input voltage. At lower values, more time will be required to raise the intermediate voltage on the storage capacitors to the level necessary to breakdown the discharger tube. However, that level being established by the physical properties of the sealed tube, a full store of energy will always be accumulated by the storage capacitors before discharge.

C. The ignition system designed for installation on the JT3D-1-MC6 engine includes two input leads, two 20-joule, intermittent duty exciters, two intermediate voltage leads, two ignition transformers, and two high tension leads. Each transformer is connected directly to an igniter. The following description covers the operation on one side of the system, (See Wiring Schematic, Figure 4).

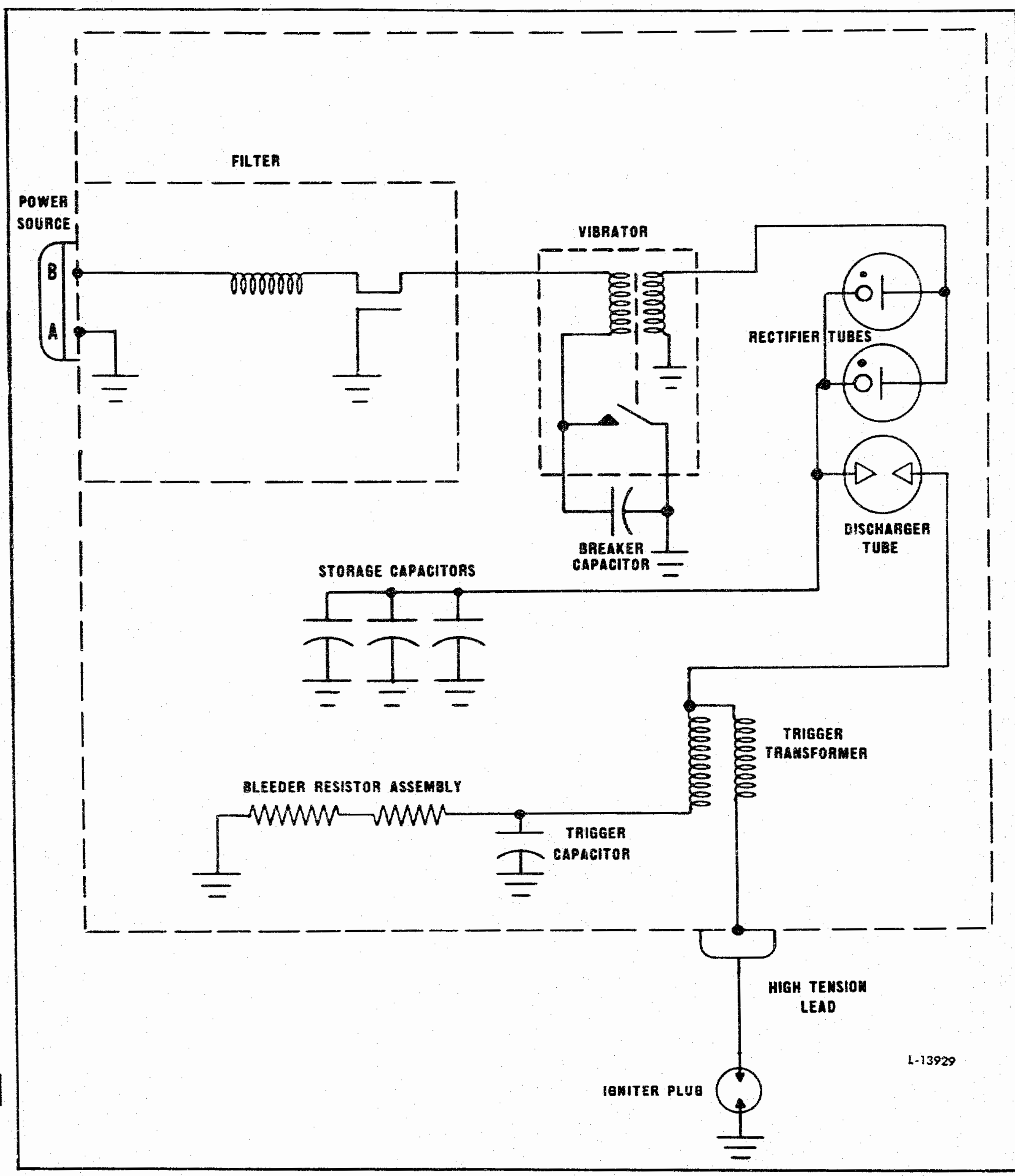
(1) The operation of the electrical circuits is identical with that described in paragraph 2B. The differences in component arrangement are as follows:

(a) There are two vibrators in each exciter, each delivering its charges to the storage capacitors through a single rectifier tube.

(b) The trigger transformer and the trigger capacitor are physically located in a separate case, and connected to the exciter by the intermediate voltage lead.

D. The ignition system designed for installation on the JT3D-3B (DL) engine is provided with a two-pin input terminal at one end, for attaching a lead from the power source. At the opposite end a high tension type of output terminal provides for attachment of a high tension lead for connection to the igniter plug. (See wiring Schematic, Figure 5 (Exciter P/N 42562).

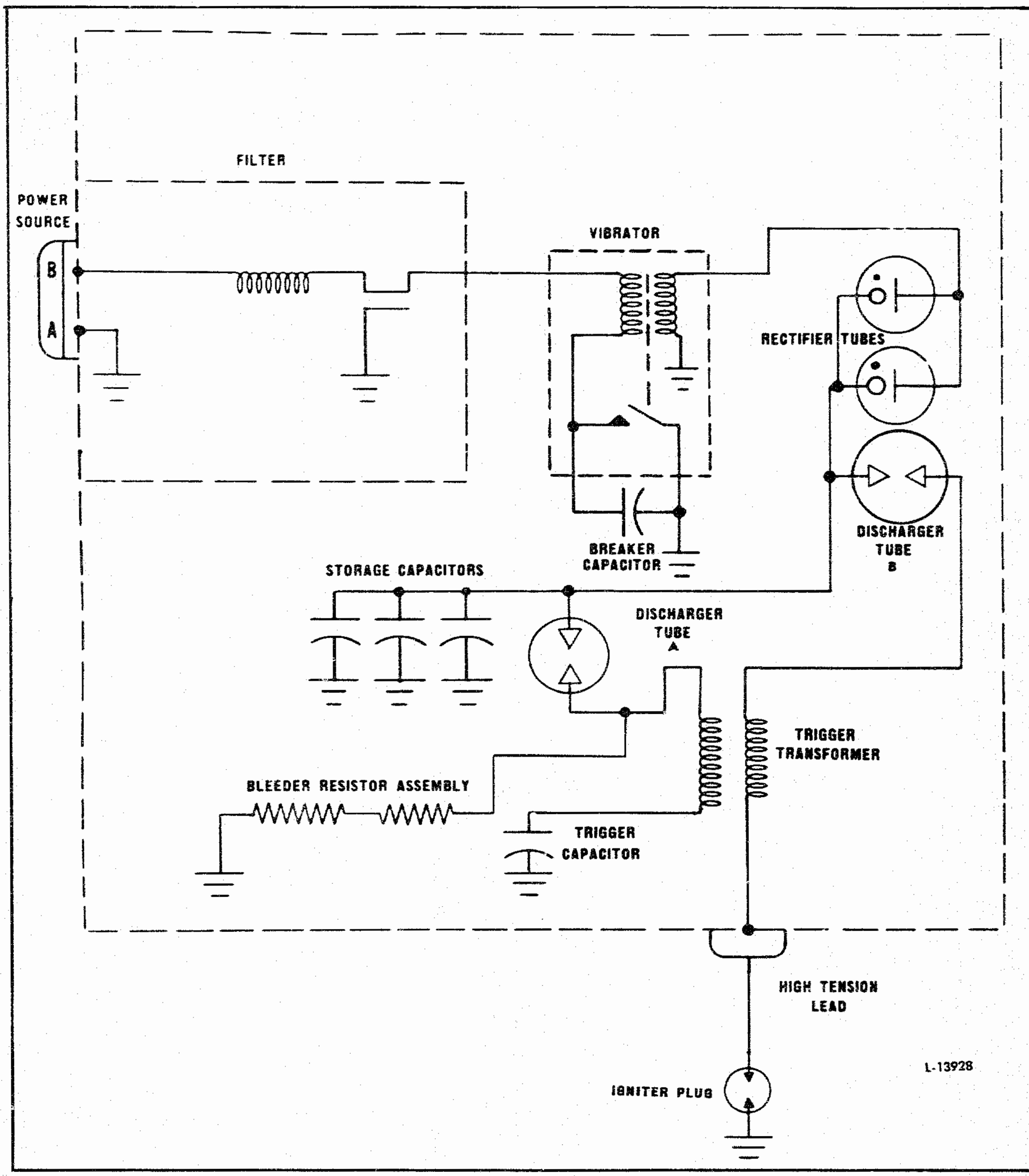
IGNITION SYSTEM - DESCRIPTION AND OPERATION



Wiring Schematic, Exciter No. 40355

Figure 2

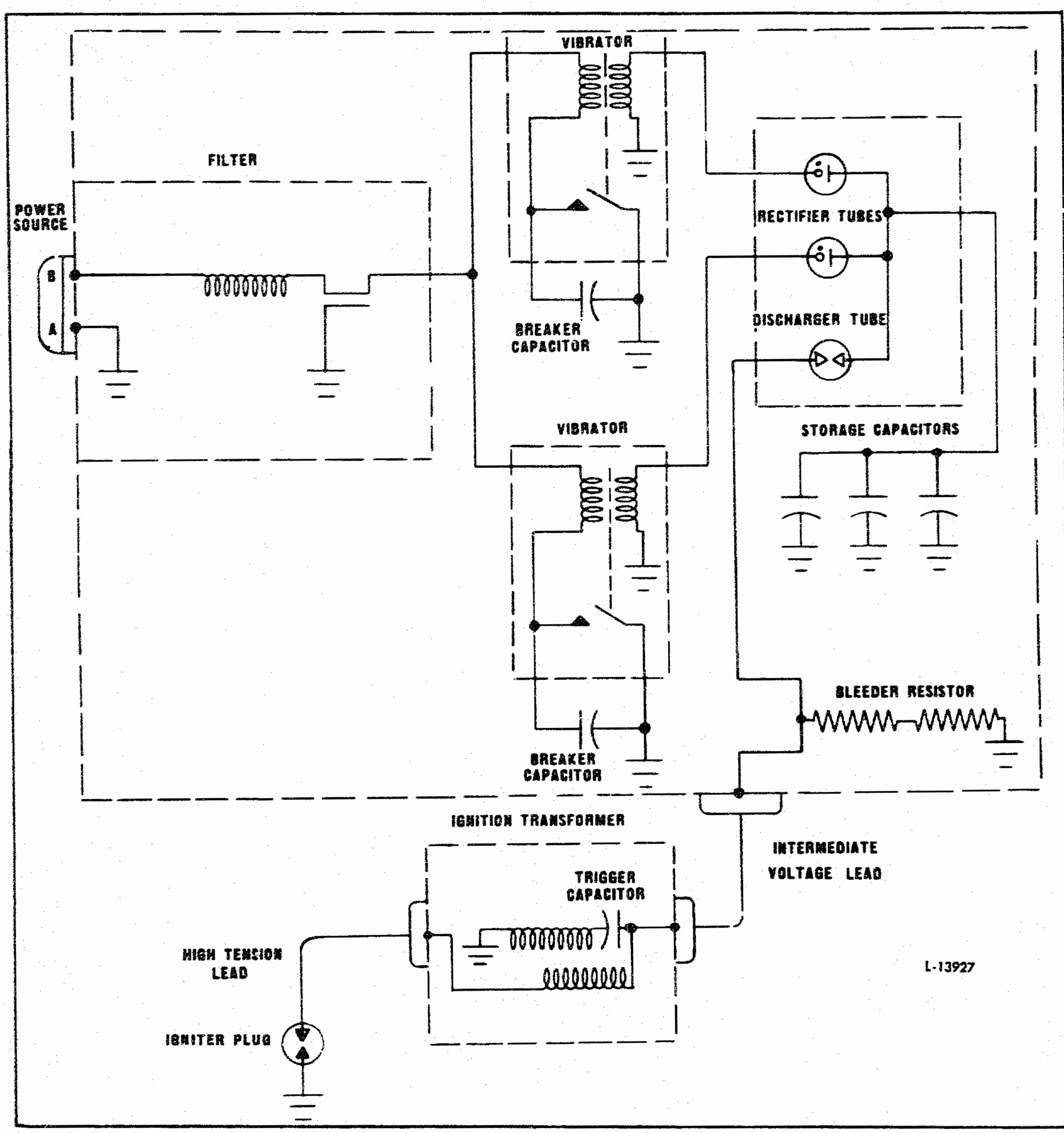
IGNITION SYSTEM - DESCRIPTION AND OPERATION



Wiring Schematic, Exciter No. 41468

Figure 3

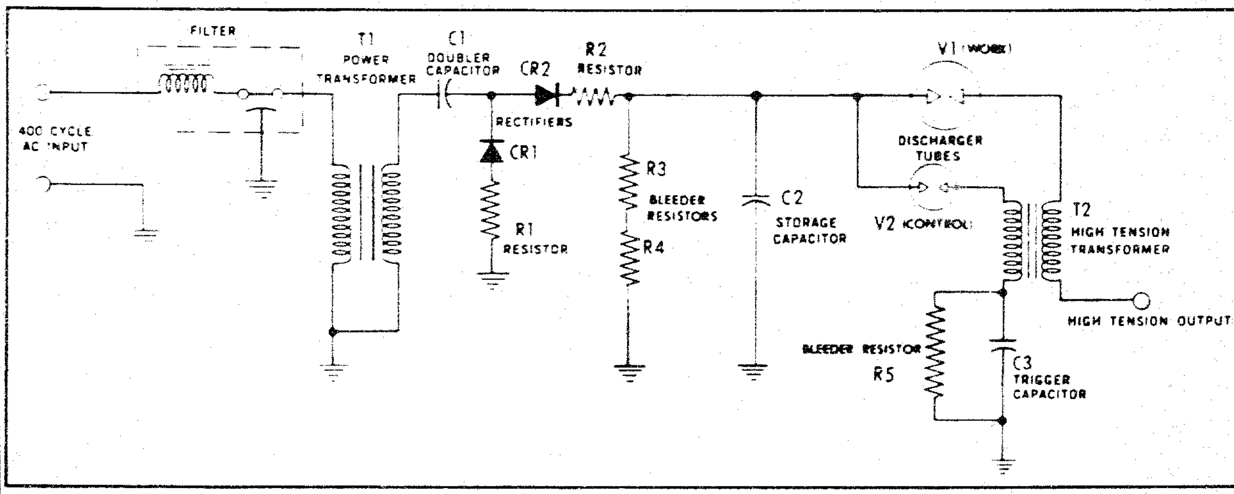
IGNITION SYSTEM - DESCRIPTION AND OPERATION



Wiring Schematic (JT3D-1-MC6 - Boeing)

Figure 4

IGNITION SYSTEM - DESCRIPTION AND OPERATION



Wiring Schematic, Exciter No. 42562
Figure 5

(1) Power is supplied to the input connector of the exciter from the 115 volt, 400 cycle source in the aircraft, and is first let through a filter, which serves to block conducted noise voltage from feeding back into the aircraft electrical system. From the filter, the input power is applied to the primary of power transformer T1 (See Figure 5). The inductor in the filter also serves as a power choke to limit the spark rate variation over the range of input voltage amplitude and frequency.

(2) Current flowing through the primary of T1 induces in the secondary a high alternating voltage. During the first half cycle, this pulse of voltage follows a path from the secondary through ground to resistor R1, rectifier CR1 and doubler capacitor C1 back to the secondary, leaving charge on C1. During the second half cycle, when polarity reverses, this circuit is blocked by CR1, the current flow is then from the secondary through C1, rectifier CR2 and storage capacitor C2 through ground to the secondary leaving C2 partially charged. Resistors R1 and R2 limit the peak current passing through the rectifiers during discharge cycle.

(3) With each pulse storage capacitor C2 thus assumes a greater and greater charge, which by virtue of the action of doubler capacitor C1 approaches a voltage approximately twice that generated in power transformer T1. When this voltage reaches the predetermined level for which the gap in discharger tube V2 (Control) has been calibrated, this gap breaks down, allowing a portion of the accumulated charge to flow through the primary of high tension transformer T2 and trigger capacitor C3, connected in series with it.

IGNITION SYSTEM - DESCRIPTION AND OPERATION

(4) This surge of current induces a very high voltage in the secondary of high tension transformer T2, sufficient to ionize the gaps in discharger tube V1 (work) and the igniter plug. Storage capacitor C2 immediately discharges the remainder of its accumulated energy through the iginiter plug. This produces a capacitive spark of very high energy.

(5) Bleeeder resistors R3 and R4 are provided as a protective measure to dissipate the residual charge on the storege capacitor when the input to the exciter is cut off.

(6) Bleeder resistor R5 is provided to dissipate the residual charge on the trigger capacitor between the completion of one discharge at the igniter plug and the succession of the next cycle.

(7) Leading particulars.

(a) Input voltage . . . Normal . . . . 115 volts, 400 cycle AC

(b) Spark rate, Minimum at normal input . . . . 0.5 per second

(c) Designed to ignite . . . . One igniter plug

(d) Accumulated energy . . . . 20 joules

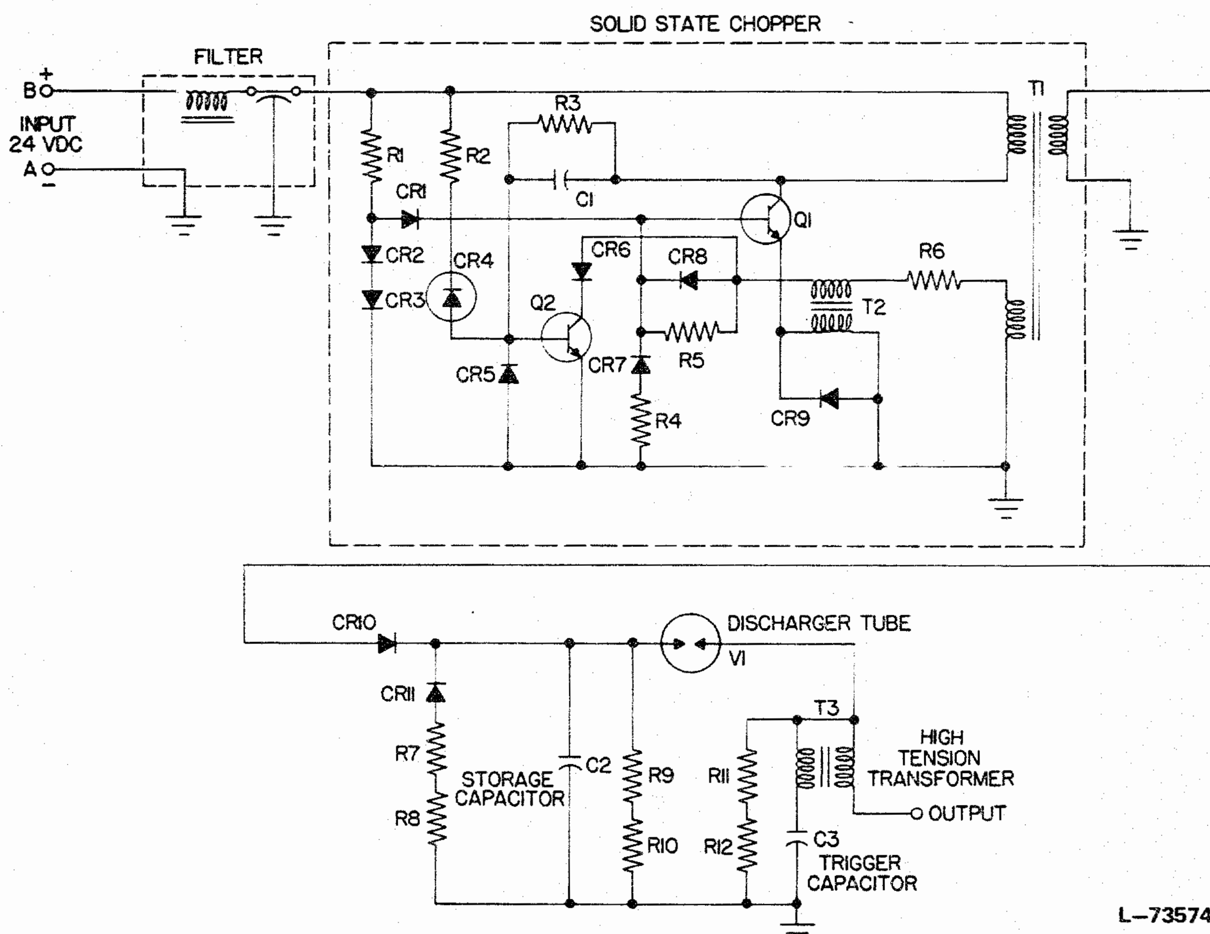
(e) Duty cycle . . . . 10 min on, 20 min off

E. Boeing engines incorporating SB 5077 have a single gap discharger tube exciter circuit in place of a dual gap discharger tube cicruit for improved engine reliability (See Figure 6).

(1) Input current (DC) passes first through a radio noise filter, which prevents high frequency feed-back into the aircraft electrical system. Current then flows through resister R1, diode CR1, base to emitter junction of power transistor Q1 and primary of transformer T2 to ground. This base current causes a flow of current through the primary of power transformer T1 and collector to emitter junction of Q1 to ground.

(2) Rising primary current produces a voltage in the feed-back winding of transformer T1, which increases the base to emitter current. This value of current is determined by resistor R6. When T1 primary current reaches the saturation value of Q1, the feed-back voltage will drop causing a decrease in the primary current; feed-back voltage polarity will reverse and cut off primary current rapidly.

IGNITION SYSTEM - DESCRIPTION AND OPERATION



Schematic PN 44387
Figure 6

IGNITION SYSTEM - DESCRIPTION AND OPERATION

(3) The base to emitter current of Q1 is regulated to a near constant value over the input voltage range by the circuit comprised of R2, CR4, Q2 and CR6. By regulating the base to emitter current, the collector to emitter current saturation point controls the exciter spark rate in respect to input voltage applied.

(4) An audio susceptibility circuit formed by T2, R3 and C1 prevents spark rate descrease under extreme audio frequency ripple in the input supply.

(5) The secondary voltage, induced by the decreasing primary current, causes current flow through CR10 and places a small charge on storage capacitor C2. This charge is retained on C2 by CR10, which limits the flow of current to a single direction. With each repeated pulse of secondary current, the charge on C2 is increased. When this charge reaches the predetermined breakdown level of discharge tube V1, the gap in the tube breaks down, allowing a portion of the accumulated charge to flow through the primary of the high tension transformer T3 and capacity C3 to ground.

(6) This surge of current induces a very high voltage in the secondary of T3, sufficient to ionize the gap at the igniter plug. The accumulated charge on the storage capacitor C2 immediately discharges through the igniter plug; resulting in a spark of extremely high energy.

(7) Bleeder Resistor R9 and R10 are provided as an additional safety factory to bleed voltage on Storage Capacitor C2 to ground at termination of each exciter operation.

(8) Resistors R11 and R12 serve to bleed off any residual charge on C3 between discharge cycles, and also act as a discharge path for C2, if for any reason, the igniter plug fails to break down.

(9) Diode CR11 and Resistors R7 and R8 are used to discharge any negative voltage left on C2 after a spark. The negative voltage would otherwise discharge slowly through the secondary of T1 and CR10 and delay the start of the next charging cycle.

(10) Leading particulars.

(a) Input voltage . . . . . . .Normal . . . . .24V DC

Operating Limits . . . . .14 to 29V DC

(b) Spark rate. . . . . .0.4 per second Minumum

(c) Designed to ignite. . . . . .1 igniter plug

(d) Accumulated energy. . . . . 20 joules

(e) Duty cycle. . . . . 10 min on, 20 min off

IGNITION SYSTEM - DESCRIPTION AND OPERATION

F. Douglas engines incorporating SB 5077 have a single gap discharger tube exciter circuit in place of a dual gap discharger tube circuit for improved component reliability. (See Figure 7).

(1) Power is supplied to the input connector of the exciter from the 115 volt, 400 cycle source in the aircraft, and is first led through a filter, which serves to block conducted noise voltage from feeding back into the aircraft electrical system. From the filter, the input power is applied to the primary of power transformer T1. The inductor in the filter also serves as a power choke to limit the spark rate variation over the range of input voltage amplitude and frequency.

(2) Current flowing through the primary of T1 induces in the secondary a high alternating voltage. During the first half cycle, this pulse of voltage follows a path from the secondary through ground to resistor R1, rectifier CR1 and doubler capacitor C1 back to the secondary, leaving a charge on C1. During the second half cycle, when polarity reverses, this circuit is blocked by CR1, the current flow is then from the secondary through C1, rectifier CR2 and storage capacitor C2 through ground to the secondary leaving C2 partially charged. Resistors R1 and R2 limit the peak current passing through the rectifiers during discharge cycle.

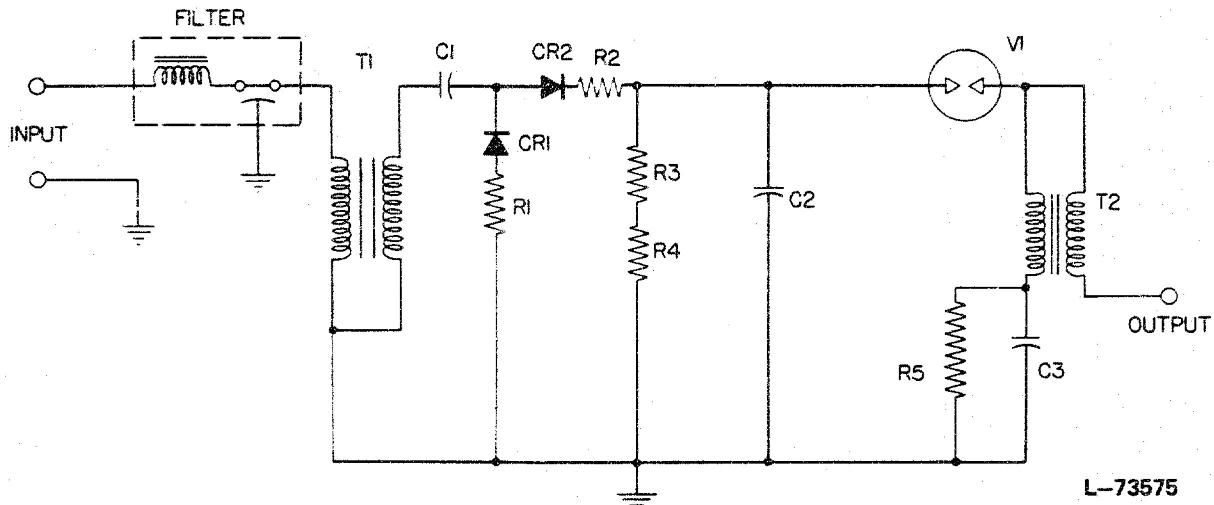
(3) With each pulse storage capacitor C2 thus assumes a greater and greater charge, which by virture of the action of doubler capacitor C1 approaches a voltage approximately twice that generated in power transformer T1. When this voltage reaches the predetermined level for which the gap in discharger tube V1 has been calibrated, this gap breaks down allowing a portion of the accumulated charge to flow through the primary of high tension transformer T2 and trigger capacitor C3, connected in series with it.

(4) This surge of current induces a very high voltage in the secondary of high tension transformer T2, sufficient to ionize the gap at the igniter plug. Storage capacitor C2 immediately discharges the remainted of its accumulated energy through the igniter plug. This produces a capacitive spark of very high energy.

(5) Bleeder resistors R3 and R34 are provided as a protective measure to dissipate the residual charge on the storage capacitor when the input to the exciter is cut off.

(6) Bleeder resistor R5 is provided to dissipate the residual charge on the trigger capacitor between the completion of one discharge at the igniter plug and the succession of the next cycle.

IGNITION SYSTEM - DESCRIPTION AND OPERATION



Schematic PN 44388
Figure 7

IGNITION SYSTEM - DESCRIPTION AND OPERATION

(7) Leading particulars.

(a) Input voltage . . . . . . .Normal . . . . . 115 volts, 400 cycle AC

(b) Apark rate, Minimum at normal input . . . . .0.5 per second

(c) Designed to ignite. . . . . .One igniter plug

(d) Accumulated energy. . . . . 20 joules

(e) Duty cycle. . . . . 10 min on, 20 min off

IGNITION SYSTEM - TROUBLESHOOTING

1. General

A. Refer to Section 72-0, Engine - Troubleshooting.

IGNITION SYSTEM - MAINTENANCE PRACTICES

1. Periodic Inspection

A. General

(1) These inspection procedures are a normal function of operating organizations. They consist of required inspection and minor adjustments necessary on the engine. The nature and conditions of engine operation determine the time interval between required inspection. For this reason, the intervals described in the Periodic Inspection Chart in this section are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because the extensive mass air flow tends to draw foreign objects into the engine. Thoroughly clean the entire engine compartment with a vacuum cleaner after completion of any work. Keep the compartment free of dirt, oil, and grease and remove any small unused parts such as nuts, washers, and pieces of lockwire. Immediately cover all apertures resulting from the disconnection of parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect the exterior of the engine without dismantling to ensure that all connections are tight.

B. Periodic Inspection Chart

WARNING: BECAUSE THE SYSTEM VOLTAGE IS DANGEROUSLY HIGH, THE IGNITION SWITCH MUST BE IN THE "OFF" POSITION BEFORE REMOVAL OF ANY OF THE IGNITION COMPONENTS. A SUFFICIENT PERIOD OF TIME (SEVERAL MINUTES) SHALL ELAPSE BETWEEN THE OPERATION OF THE IGNITION SYSTEM AND THE REMOVAL OF COMPONENTS. AS AN ALTERNATIVE, IMMEDIATELY UPON DETACHING LEAD FROM IGNITER, DISCHARGE THE CURRENT BY GROUNDING THE TERMINAL. THIS IS TO ENSURE THE COMPLETE DISSIPATION OF ENERGY FROM THE SYSTEM.

IGNITION SYSTEM - MAINTENANCE PRACTICES

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
Ignition Leads	a. Chafing, wear and security.	X	X	X
	b. Continuity electrical check (see item c under Igniters).	X	X	X
Exciters (DC and AC)	a. Security of mounting.	X	X	X
	b. Loss of hermetic seal.		X	X
	c. Continuity electrical check (see item c under Igniters).	X	X	X
Discharger Assembly (Continuous Ignition Duty)	a. Replace the discharger assembly at intervals not exceeding 300 hours of continuous ignition operation. See 74-1-0.			
Igniter Plugs	a. Abnormal condition of electrodes and ceramic for cracks.		X	X
	b. Depth of center electrode for erosion.		X	X
	NOTE: For igniters used in continuous ignition duty check erosion of the ground shell which is manifested by enlarged annular gap and/or undercutting of the ceramic surface. Replace igniter at intervals, as necessary, but not to exceed 200 hours of continuous ignition operation.			
	c. Aural check of sparking. (This serves as continuity check for ignition components and wiring).	X	X	X
	CAUTION: IMMEDIATELY PRIOR TO ATTEMPTING THIS TEST THE "CLEAR ENGINE PROCEDURE" MUST BE COMPLIED WITH. SEE 72-0, ADJUSTMENT/TEST.			

IGNITION EXCITERS - DESCRIPTION

General

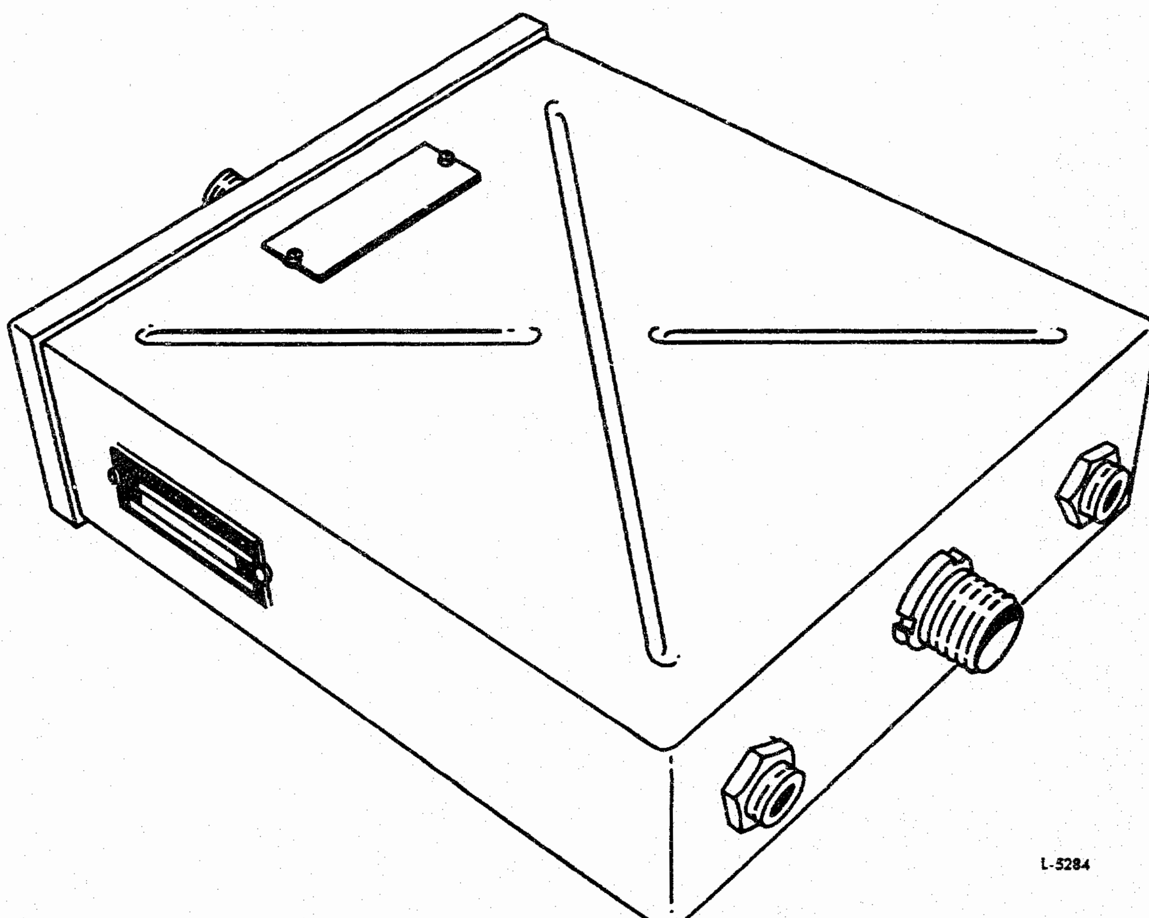
The function of the exciters is to change low tension current to high tension current and store it for release to the igniters.

Description

See Figure 1.

There are two basic types of exciters used on the JT3D engines.

DC exciters perform a starting (intermittent duty) function on all engine models. The exciters receive low tension current from the aircraft electrical supply, and discharge high tension current through the high tension leads to the igniters. On the JT3D-1-MC6 engines, the trigger transformer and trigger capacitor are located in a separate transformer case which is connected to the exciter by an intermediate voltage lead. The high tension lead connects the transformer to the igniter on this engine model.



Ignition Exciter (DC)
Figure 1

IGNITION EXCITERS - DESCRIPTION

AC exciters perform an in-flight (continuous duty) function on JT3D-1 and JT3D-3 Douglas engines. The purpose of the AC ignition system is to provide continuous ignition to one igniter during unfavorable flight conditions when the possibility of unpredictable flameout exists.

IGNITION EXCITERS - MAINTENANCE PRACTICES

1. General

The following precautions shall be observed by personnel engaged in servicing of ignition exciter units.

WARNING: BECAUSE SYSTEM VOLTAGE IS DANGEROUSLY HIGH, IGNITION SWITCH MUST BE IN "OFF" POSITION BEFORE REMOVAL OF ANY OF IGNITION COMPONENTS. SUFFICIENT PERIOD OF TIME (SEVERAL MINUTES) SHALL ELAPSE BETWEEN OPERATION OF IGNITION SYSTEM AND REMOVAL OF COMPONENTS: OR IMMEDIATELY UPON DETACHING LEAD FROM IGNITERS, DISCHARGE CURRENT BY GROUNDING TERMINAL. THIS IS TO ENSURE COMPLETE DISSIPATION OF ENERGY FROM SYSTEM.

CAUTION: DO NOT SUPPLY MECHANICAL CURRENT TO IGNITION UNIT UNLESS IGNITERS ARE CONNECTED TO UNIT.

2. Removal/Installation of Ignition Exciters - (JT3D-1, JT3D-3, or JT3D-3B, Douglas)

NOTE: See Paragraph 4 for JT3D-3B (DL).

A. Removal/Installation of Intermittent Duty (DC) Exciter.

(1) Removal

(a) Disconnect two high tension leads and intermediate voltage lead from exciter.

(b) Remove bolts, locknuts and spacers securing ignition exciter brackets to compressor case brackets.

(c) Remove exciter.

(d) Cut lockwire and remove bolts securing brackets to exciter.

(2) Installation

(a) Secure ignition exciter brackets to exciter with bolts. Tighten to recommended torque and lockwire.

(b) Position exciter brackets (installed on exciter) on compressor front case brackets with PN 267211 Spacers (4) located between brackets. Align bolt holes and hold assembly in place.

(c) Install bolts down through aligned holes; then secure them with locknuts. Tighten locknuts to recommended torque.

IGNITION EXCITERS - MAINTENANCE PRACTICES

(d) Connect the two high tension leads and the intermediate voltage lead to the exciter. Tighten the connector until shoulder bottoms (approximately 140 to 160 pound-inches).

B. Removal/Installation of the Continuous Duty (AC) Exciter

(1) Removal

(a) Disconnect the continuous duty to intermittent duty exciter intermediate voltage lead.

(b) Remove the bolts, locknuts and spacers securing the ignition exciter brackets to the compressor case brackets.

(c) Remove the exciter.

(d) Remove the bolts securing the brackets to the exciter.

(2) Installation

(a) Secure the ignition exciter brackets to the exciter with the bolts. Tighten to the recommended torque.

(b) Position the exciter brackets (installed on the exciter) on the compressor front case brackets and align the bolt holes.

(c) Place the spacers on the bolts and install them down through the aligned holes; then secure them with the locknuts. Tighten to the recommended torque.

(d) Attach the intermediate voltage lead. Tighten the connector until shoulder bottoms (approximately 140 to 160 pound-inches).

3. Removal/Installation of the Ignition Exciters - (JT3D-1 Boeing or JT3D-3 Boeing, JT3D-3B Boeing or JT3D-1-MC6 QANTAS, or JT3D-1-MC7)

A. Removal

(1) Disconnect the input and high tension leads from the upper ignition exciter located on the upper right hand section on the middle and rear flanges of the front compressor rear case.

(2) Remove the four bolts securing the upper ignition exciter to the bracket assemblies.

NOTE: Mark the position of the loop clamp angle bracket on the rear bracket assembly to assure its installation in the same position.

IGNITION EXCITERS - MAINTENANCE PRACTICES

(3) Remove the upper exciter.

(4) Using the same procedure, remove the lower exciter.

B. Installation

(1) Position the lower ignition exciter in the lower section of the bracket assemblies located on the upper right section of the front compressor rear case.

(2) Align the bolt holes; then install the bolts securing the exciter to the bracket assemblies. Tighten the bolts to the recommended torque and lockwire.

(3) Connect the input lead, tighten connector finger tight plus an additional 45 degree turn maximum, and lockwire. Connect the high tension lead and tighten the connector until shoulder bottoms (approximately 140 to 160 pound-inches).

(4) Install the upper ignition exciter in a similar manner.

NOTE: Position the loop clamp angle bracket beneath the lower rear bolt which secures the upper ignition exciter.

4. Removal/Installation of Ignition Exciters (JT3D-3B-DL)

A. Removal

(1) Disconnect ignition cables at exciters.

(2) Remove bolts and locknuts securing exciters to front compressor front case brackets.

(3) Remove exciters and their brackets.

B. Installation

(1) Secure two ignition exciters together with bolts and nuts. Torque nuts.

(2) Secure ignition exciter front and rear brackets to exciters with bolts. Torque and lockwire bolts.

(3) Install exciters and brackets onto flange bolts located between flanges of front compressor front case at approximate three o'clock position. Secure with bolts and nuts and torque.

(4) Connect ignition cables to exciters and tighten connectors until shoulder bottoms (approximately 140 to 160 pound inches).

IGNITION EXCITERS - MAINTENANCE PRACTICES

5. Removal/Installation of the Ignition Exciters (JT3D-1-MC6 - Boeing)

A. Removal

(1) Disconnect the input lead and intermediate voltage lead from the upper exciter which is located on the upper right side of the front compressor rear case.

(2) Remove the four bolts which secure the exciter to the front and rear mounting brackets.

NOTE: Mark the position of the loop clamp angle bracket on the rear bracket assembly to assure its installation in the same position.

(3) Remove the exciter.

(4) Using the same procedure, remove the lower exciter.

B. Installation

(1) Position the lower exciter between the front and rear mounting brackets.

(2) Align the bolt holes in the exciter with the mating bolt holes in the brackets. Install, tighten, and lockwire the four bolts to secure the exciter.

(3) Connect the input lead and tighten the connector finger tight plus an additional 45 degree turn maximum. Connect the intermediate voltage lead and tighten connector until shoulder bottoms (approximately 140 to 160 pound-inches).

(4) Using the same procedure, install the upper exciter.

NOTE: Position the loop clamp angle bracket beneath the lower rear bolt which secures the upper exciter.

6. Removal/Installation of Discharger Assembly from Continuous Duty Exciter (JT3D-1 and JT3D-3 Douglas)

A. Removal

(1) Cut the lockwire and unscrew the coupling nut without removing the retaining ring. This will draw out the discharger assembly.

(2) Remove discharger assembly and return to overhaul facility properly tagged.

IGNITION EXCITERS - MAINTENANCE PRACTICES

B. Installation

(1) Install a new discharger assembly.

(2) Tighten the coupling nut and lockwire.

IGNITION EXCITERS - INSPECTION/CHECK

1. Ignition Exciters - Inspection

A. Inspection

(1) Visually inspect exciter case and brackets for cracks and physical damage.

(2) Visually inspect terminal outlets for thread damage.

(3) Visually inspect well of output receptacle for damage or carbon track on ceramic.

IGNITION EXCITERS - CLEANING/PAINTING

1. Ignition Exciters - Cleaning

A. Cleaning

(1) Clean receptacle well with methylethylketone using a non-metalic applicator.

(2) Dry with compressed air.

IGNITION TRANSFORMERS - DESCRIPTION

General

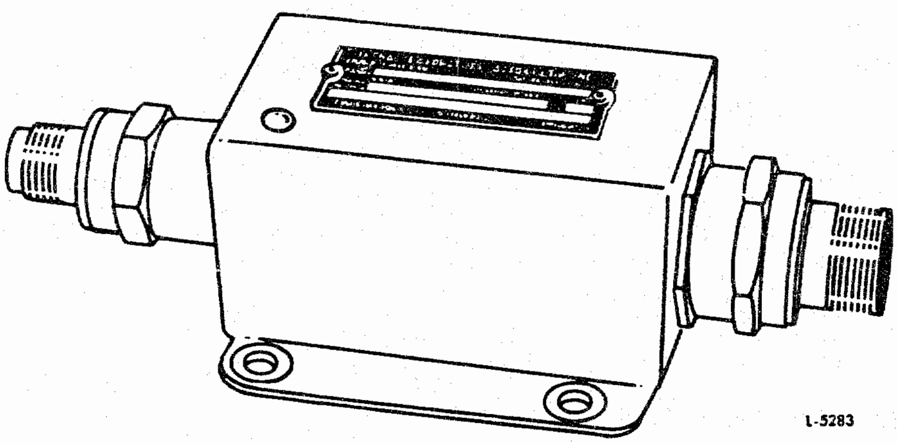
The function of the transformers is to change the high voltage from the exciters to very high tension. This very high voltage breaks down the resistance of the igniter gap and ionizes it to permit the entire stored charge to jump the gap. Separately mounted transformers are used on JT3D-1-MC6 engines only.

Description

See Figure 1.

The ignition transformer (one for each circuit) consists of the high tension or trigger transformer, capacitor, and spark gap and is housed in a single metal container.

Two independent transformers are mounted on the lower right side of the front compressor rear case. The complete units are sealed to protect all components from adverse operating conditions and to eliminate the possibility of flashover at altitude because of pressure changes.



Ignition Transformer

Figure 1

IGNITION TRANSFORMERS - MAINTENANCE PRACTICES

1. General

The following precautions shall be observed by personnel engaged in the servicing of ignition transformers.

NOTE: Do not supply electrical current to ignition units unless the igniters are connected to the transformers.

WARNING: BECAUSE THE SYSTEM VOLTAGE IS DANGEROUSLY HIGH, THE IGNITION SWITCH MUST BE IN THE "OFF" POSITION BEFORE REMOVAL OF ANY OF THE IGNITION COMPONENTS. A SUFFICIENT PERIOD OF TIME (SEVERAL MINUTES) SHALL ELAPSE BETWEEN THE OPERATION OF THE IGNITION SYSTEM AND THE REMOVAL OF COMPONENTS; OR IMMEDIATELY UPON DETACHING LEAD FROM IGNITER DISCHARGE THE CURRENT BY GROUNDING THE TERMINAL. THIS IS TO ENSURE COMPLETE DISSIPATION OF ENERGY FROM THE SYSTEM.

2. Removal/Installation of Ignition Transformers (JT3D-1-MC6)

A. Removal

(1) Disconnect the intermediate voltage and high tension leads from each of the two ignition transformers which are located on the lower right side of the front compressor rear case.

(2) Remove the four bolts and locknuts which secure each transformer to the mounting bracket.

(3) Remove the transformer.

B. Installation

(1) Align the bolt holes in the transformer with the mating holes in the mounting bracket. Install the four bolts and secure with the locknuts.

(2) Connect the intermediate and high voltage leads to the transformer. Tighten the connectors until shoulder bottoms (approximately 140 to 160 pound-inches).

(3) Repeat the installation procedure for the remaining transformer.

INTERMEDIATE VOLTAGE LEADS - DESCRIPTION

1. Description

A. The ignition intermediate voltage lead consists of an electrical cable encased in a braided conduit with cigarette-type connectors at both ends. The leads and connectors are shielded to prevent radio interference.

(1) Two intermediate voltage leads are used on the JT3D-1-MC6 engines. The leads conduct boosted electrical charges from the ignition exciters to the ignition transformers.

(2) One intermediate voltage lead is used on Douglas JT3D-1, -3, and -3B engines. The lead conducts boosted voltage from the continuous duty exciter to the intermittent duty exciter.

NOTE: The continuous duty exciter is used when aircraft is in flight

INTERMEDIATE VOLTAGE LEADS - MAINTENANCE PRACTICES

1. General

The following precaution shall be observed by personnel engaged in the servicing of intermediate voltage leads.

WARNING: BECAUSE THE SYSTEM VOLTAGE IS DANGEROUSLY HIGH, THE IGNITION SWITCH MUST BE IN THE "OFF" POSITION BEFORE REMOVAL OF ANY OF THE IGNITION COMPONENTS. A SUFFICIENT PERIOD OF TIME (SEVERAL MINUTES) SHALL ELAPSE BETWEEN OPERATION OF THE IGNITION SYSTEM AND THE REMOVAL OF COMPONENTS; OR IMMEDIATELY UPON DETACHING LEAD FROM IGNITER, DISCHARGE THE CURRENT BY GROUNDING THE TERMINAL. THIS IS TO ENSURE COMPLETE DISSIPATION OF ENERGY FROM THE SYSTEM.

2. Removal/Installation of Intermediate Voltage Leads (JT3D-1-MC6)

A. Removal

(1) Unfasten the intermediate voltage leads from the exciters.

(2) Remove the clips from the intermediate voltage leads and note their location.

(3) Unfasten the lead connectors at both ignition transformers and remove the leads.

B. Installation

(1) Fasten the longer intermediate voltage lead to the top exciter and to the lower connection on the right transformer. Secure the lead to the engine with the clips, the locations of which were noted at disassembly. Tighten the screws and nuts of the clips to the recommended torque.

(2) Fasten the shorter intermediate voltage lead to the bottom exciter and to the upper connection on the left transformer. Secure the lead to the engine with the clips, the locations of which were noted at disassembly. Tighten the screws and nuts of the clips to the recommended torque.

(3) Tighten the connectors until shoulder bottoms (approximately 140 to 160 pound-inches).

3. Removal/Installation of the Intermediate Voltage Lead (JT3D-1 Douglas, JT3D-3 Douglas or JT3D-3B Douglas)

A. Removal

(1) Unfasten the intermediate voltage lead from the intermittent duty DC exciter.

INTERMEDIATE VOLTAGE LEADS - MAINTENANCE PRACTICES

(2) Remove the clips from the intermediate voltage lead and note their location.

(3) Unfasten the intermediate voltage lead from the continuous duty AC exciter.

B. Installation

(1) Fasten the intermediate voltage lead to the DC exciter.

(2) Secure the lead to the engine with the clips, the locations of which were noted at disassembly.

(3) Fasten the lead to the AC exciter.

(4) Tighten the connectors until shoulder bottoms (approximately 140 to 160 pound-inches).

HIGH TEMSION LEADS - DESCRIPTION

1. Description

   A. The ignition high tension leads (two) consist of electrical cable encased in braided conduit with cigarette-type connectors at both ends. The leads and connectors are shielded to prevent radio interference. The conduct the high tension electrical charge from the exciters to the igniters (from the transformers to the igniters on the JT3D-1-MC6).

   B. High tension leads that have accumulated any engine time must have rubber bushings replaced at both ends at maintenance level. Replacement of bushings will ensure control of flashover. See Inspection/Check Paragraph 1.A.(2)(b).

HIGH TENSION LEADS - MAINTENANCE PRACTICES

1. General

A. The following precaution shall be observed by personnel engaged in servicing of high tension leads.

WARNING: BECAUSE SYSTEM VOLTAGE IS DANGEROUSLY HIGH, IGNITION SWITCH MUST BE IN "OFF" POSITION BEFORE REMOVAL OF ANY IGNITION COMPONENTS. SUFFICIENT PERIOD OF TIME (SEVERAL MINUTES) SHALL ELAPSE BETWEEN OPERATION OF IGNITION SYSTEM AND REMOVAL OF COMPONENTS; OR IMMEDIATELY UPON DETACHING LEAD FROM IGNITER PLUG, DISCHARGE CURRENT BY GROUNDING TERMINAL. THIS IS TO ENSURE COMPLETE DISSIPATION OF ENERGY FROM SYSTEM.

2. Removal/Installation - High Tension Leads

A. Removal

CAUTION: DO NOT TWIST HIGH TENSION LEAD WHEN TURNING NUTS. LEADS WILL BE DAMAGED.

(1) Unfasten high tension leads from igniters and from exciters (from transformers on JT3D-1-MC6 engines).

(2) Remove clips from high tension leads and note their location.

(3) Replace and discard rubber bushing from both ends of lead. See Paragraph 3.

(4) Perform high tension contact and cable inspection during rubber bushing replacement. See Inspection/Check.

B. Ignition Leads Installation (JT3D-1 Boeing, JT3D-3 Boeing, and JT3D-3B Boeing)

(1) General

(a) Insufficient torque on lead nuts at exciter and igniter plug ends can cause ignition radiated noise and cause interference with aircraft electronic equipment.

(2) Procedure

NOTE: Ensure that cable has new rubber bushing. See Description Paragraph 1.B.

HIGH TENSION LEADS - MAINTENANCE PRACTICES

CAUTION: DO NOT TWIST HIGH TENSION LEAD WHEN TURNING NUT. LEAD WILL BE DAMAGED.

(a) Position left igniter lead on engine and connect nut to left igniter plug. Torque nut, 140 - 160 pound-inches.

(b) Route lead forward, crossing underneath engine, and routing it to upper exciter. Install clips to brackets and adjacent tubing locations as noted at disassembly. Torque clip screws. See Standard Practice Manual.

CAUTION: DO NOT TWIST HIGH TENSION LEAD WHEN TURNING NUT. LEAD WILL BE DAMAGED.

(c) Connect lead nut to exciter. Torque nut 140 - 160 pound-inches.

(d) Position right igniter lead on engine and connect nut to right igniter plug. Torque nut 140 - 160 pound-inches.

(e) Route lead forward to lower exciter. Install clips to brackets and adjacent tubing locations as noted at disassembly Torque clip screws. See Standard Practices Manual.

(f) Connect igniter lead. Torque nut 140 - 160 pound-inches.

C. Ignition Leads - Installation (JT3D-1 Douglas, JT3D-3 Douglas, JT3D-3B Douglas, JT3D-1-MC6, and JT3D-1-MC7).

NOTE: See Paragraph D. for JT3D-3B-DL engines.

(1) General

(a) Insufficient torque on lead nuts at exciter and igniter plug ends can cause ignition radiated noise and cause interference with aircraft electronic equipment.

(2) Procedure

NOTE: Ensure that cable has new rubber bushings. See Description Paragraph 1.B.

CAUTION: DO NOT TWIST HIGH TENSION LEAD WHEN TURNING NUTS. LEAD WILL BE DAMAGED.

(a) Position left igniter lead on engine and connect nut to left igniter plug. Torque nut 140 - 160 pound-inches.

HIGH TENSION LEADS - MAINTENANCE PRACTICES

(b) Route lead forward, crossing underneath engine, and routing it to lower exciter. (On JT3D-1-MC6, route left igniter lead to rear transformer). Install clips to brackets and adjacent tubing. Torque clip screws. See Standard Practices Manual.

CAUTION: DO NOT TWIST HIGH TENSION LEAD WHEN TURNING NUT. LEAD WILL BE DAMAGED.

(c) Connect lead nut to exciter (on JT3D-1-MC6 connect lead nut to transformer). Torque nut 140 - 160 pound-inches.

(d) Install right igniter lead in same manner, routing it along right side of engine. (On JT3D-1-MC6, route right igniter lead to front transformer.) On JT3D-1 Douglas, JT3D-3 Douglas, JT3D-3B Douglas, and JT3D-1-MC7 route right exciter lead to lower exciter.

(e) Position cable on engine between lower and upper exciter. (On the JT3D-1-MC6, position two cables, one at a time. First between upper exciter and right transformer. Second between lower exciter and left transformer.)

CAUTION: DO NOT TWIST HIGH TENSION LEAD WHEN TURNING NUT. LEAD WILL BE DAMAGED.

(f) Install clips to brackets and adjacent tubing. Torque clip screws. See Standard Practices Manual. Torque nut 140 - 160 pound-inches.

D. Ignition Leads - Installation (JT3D-3B-DL)

(1) General

(a) Insufficient torque on lead nuts at exciter and igniter plug ends can cause ignition radiated noise and cause interference with aircraft electronic equipment.

(2) Procedure

NOTE: Ensure that cable has new rubber bushings. See Description Paragraph 1.B.

CAUTION: DO NOT TWIST HIGH TENSION LEAD WHEN TURNING NUT. LEAD WILL BE DAMAGED.

(a) Position left igniter plug-to-exciter cable on engine and connect nut to left igniter plug. Torque nut 140 - 160 pound-inches.

(b) Route cable forward, crossing underneath engine, and routing it to lower exciter. Install clips to brackets and tubing. Torque clip screws. See Standard Practices Manual.

CAUTION: DO NOT TWIST HIGH TENSION LEAD WHEN TURNING NUT. LEAD WILL BE DAMAGED.

(c) Connect lead nut to exciter. Torque nut 140 - 160 pound-inches.

(d) Install right igniter plug-to-exciter cable in same manner, routing it along right side of engine.

3. High Tension Lead Terminal Bushing Replacement

See Figure 201.

A. Removal

(1) Remove and discard retaining ring from high tension contact.

(2) Slide insulator, rubber bushing, and spring from cable wire. Discard bushing.

NOTE: Replace insulator and/or spring if damaged.

(3) Clean reusable detail parts. See Cleaning.

WARNING: USE CLEANING SOLVENT IN WELL VENTILATED AREA. AVOID CONTACT WITH SKIN.

(4) Clean new rubber bushing with clean lint free coth moistend with PMC 9056 (1,1,1-Trichloroethane, Inhibited).

B. Installation

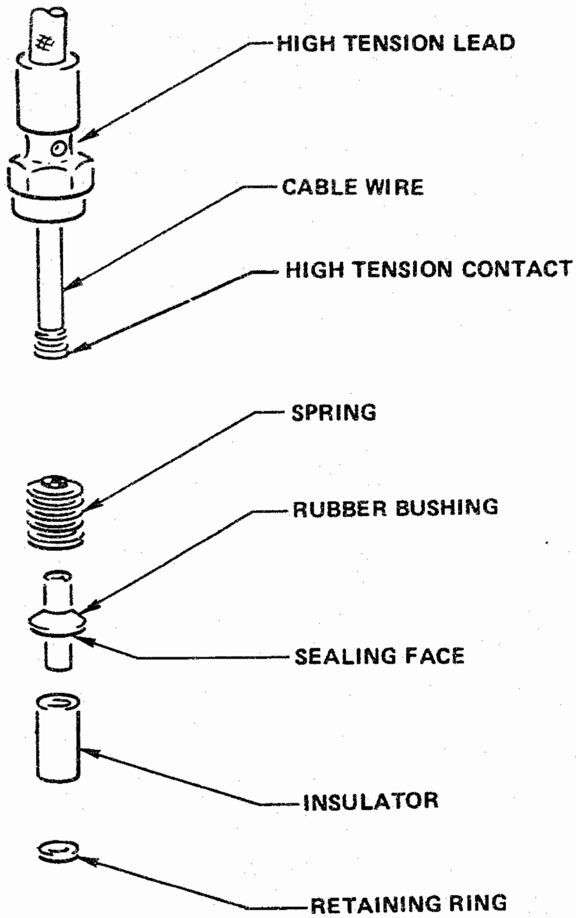
(1) Slide spring, clean new rubber bushing, and insulator on cable wire and secure in place with new retaining ring in groove of high tension contact.

(2) Apply light coat of Krytox 240AC grease to sealing face of rubber bushing.

NOTE: Grease may also be used between bushing and cable wire for ease of installation. Krytox 240AC grease is available from DuPont E.I. DeNemours & Co. Inc., Industrial And Biochemical Department, 1007 Market Street, Wilmington, Delaware 19898 U.S.A.

(3) No grease is allowed externally on insulator or other details of lead.

HIGH TENSION LEADS - MAINTENANCE PRACTICES



Rubber Bushing Replacement
Figure 201

HIGH TENSION LEADS - INSPECTION /CHECK

1. High Tension Leads - Inspection

A. Procedure

(1) Visually inspect wire braid for cuts, abrasion, or other damage and coupling nuts for worn or stripped threads. If indications are evident, send assembly to repair facility.

(2) During rubber bushing replacement. See Figure 601.

(a) Visually inspect high tension contact for arcing. Arcing is identified by discoloration or pitting. Remove discoloration per Cleaning. If contact cannot be cleaned or severe pitting is evident, send assembly to repair facility.

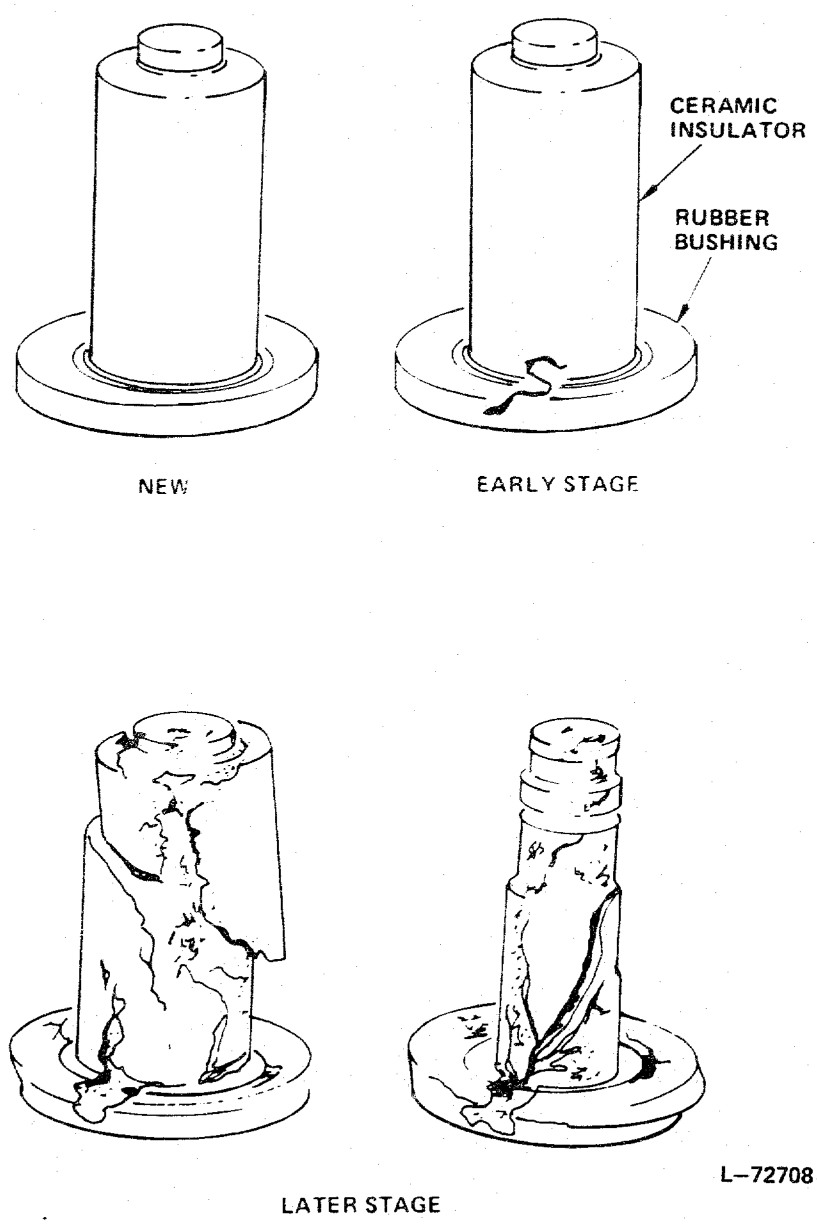
(b) Visually inspect ceramic insulator for flashover. Flashover is identified by carbon tracking. See Figure 601. If carbon tracking is evident, send assembly to repair facility.

(c) Visually inspect if cable wire insulation is hard, brittle, or cracked. If insulation damage is evident, send assembly to repair facility.

(d) Visually inspect for presence of oil, dirt, or conductive contaminants on exposed parts. Clean per Cleaning.

(e) Visually inspect insulator and spring. Replace if damaged.

HIGH TENSION LEADS - INSPECTION /CHECK



Ceramic Insulator Flashover Damage
Figure 601

HIGH TENSION LEADS - CLEANING

1. Cleaning

A. General

(1) Compressed air shall be maintained at 30 psig maximum pressure.

B. Procedure
See Figure 201

(1) Remove dirt or foreign matter from area inside spring using compressed air.

WARNING: USE CLEANING SOLVENT IN WELL VENTILATED AREA. AVOID CONTACT WITH SKIN.

NOTE: Cleaning solvent shall be PMC 9056 (1,1,1-Trichloroethane, Inhibited) and is locally available.

(2) Wipe ceramic insulator clean using clean lint-free cloth moistened with cleaning solvent. Dry with compressed air.

(3) Wipe wire braid with clean lint-free cloth moistened with cleaning solvent. Dry with compressed air.

(4) Clean high tension contact as required with clean lint-free solvent. Dry with compressed air.

INPUT LEADS - DESCRIPTION

Description

The input leads (two) consist of electrical cable encased in a braided conduit. The leads and connectors are shielded to prevent radio interference. The function of the leads is to supply power from the aircraft power supply to the ignition system.

INPUT LEADS - MAINTENANCE PRACTICES

1. General

The following precaution shall be observed by personnel engaged in the servicing of input leads.

WARNING: BECAUSE THE SYSTEM VOLTAGE IS DANGEROUSLY HIGH, THE IGNITION SWITCH MUST BE IN THE "OFF" POSITION BEFORE REMOVAL OF ANY OF THE IGNITION COMPONENTS. A SUFFICIENT PERIOD OF TIME (SEVERAL MINUTES) SHALL ELAPSE BETWEEN THE OPERATION OF THE IGNITION SYSTEM AND THE REMOVAL OF COMPONENTS; OR IMMEDIATELY UPON DETACHING LEAD FROM IGNITER, DISCHARGE THE CURRENT BY GROUNDING THE TERMINAL. THIS IS TO ENSURE THE COMPLETE DISSIPATION OF ENERGY FROM THE SYSTEM.

2. Removal/Installation of Input Leads (Not Applicable to JT3D-1 or JT3D-3 Douglas)

A. Removal

(1) Unfasten the input leads from the ignition exciters, and remove the screws securing the leads to the ignition exciter bracket.

B. Installation

(1) Fasten one end of the input leads to the ignition exciters and secure the opposite ends to the ignition exciter bracket with screws. Tighten the ends secured to the ignition exciters finger tight plus an additional 45 degree turn maximum and lockwire.

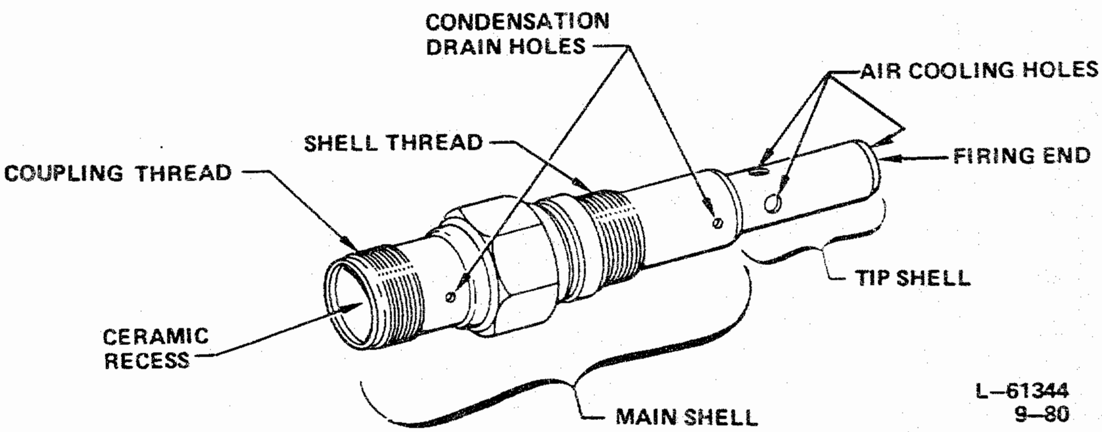
IGNITER PLUGS - DESCRIPTION

Description

See Figure 1.

There are two igniters, one each inserted in the number 4 and 5 combustion chambers. The balance of the combustion chambers are interconnected by flame tubes as described in Section 72-0. The igniters pass through holes in the lower rear of the diffuser case.

The igniters provide the gap across which the electrical spark passes to ignite the gas. This is accomplished by the surge of the very high voltage of the triggering transformers across the igniter gap which ionizes the gap and makes it conductive; then the storage capacitor discharges the remainder of its accumulated energy through the triggering transformer. This results in a capacitive spark of very high energy, capable of vaporizing globules of fuel and overcoming carbonaceous deposits.



Igniter Plug
Figure 1

IGNITER PLUGS - REMOVAL/INSTALLATION

1. Removal/Installation of Igniters

The following precaution shall be observed by personnel engaged in the servicing of igniter plugs.

WARNING: BECAUSE SYSTEM VOLTAGE IS DANGEROUSLY HIGH, IGNITION SWITCH MUST BE IN "OFF" POSITION BEFORE REMOVAL OF ANY IGNITION COMPONENTS. A SUFFICIENT PERIOD OF TIME (SEVERAL MINUTES), SHALL ELAPSE BETWEEN OPERATION OF IGNITION SYSTEM AND REMOVAL OF COMPONENTS; OR IMMEDIATELY UPON DETACHING LEAD FROM IGNITERS, DISCHARGE CURRENT BY GROUNDING TERMINAL. THIS IS TO ENSURE COMPLETE DISSIPATION OF ENERGY FROM SYSTEM.

CAUTION: IT MAY BE NECESSARY TO REPLACE IGNITER PLUG IF DROPPED BECAUSE OF INTERNAL DAMAGE.

Note: If igniter plug is removed, igniter plug terminal well shall be cleaned prior to installation.

A. Removal

(1) Using wrench, remove right igniter from its well in diffuser case.

(2) Remove left igniter in same manner.

B. Installation

CAUTION: THIS MUST BE DONE WITH CARE TO PRECLUDE THE POSSIBILITY OF DISLODGING THE NO. 4 AND/OR NO. 5 COMBUSTION CHAMBERS, CAUSING SUBSEQUENT DAMAGE. IF DIFFICULTY IS ENCOUNTERED INSTALLING SPARKIGNITERS, CHECK DIFFUSER CASE THREADS. IF NECESSARY, CHASE THREADS USING PWA 8597 TAP.

(1) Coat threads with BG Mica Lube A-768 Anti-Seize Compound. With heatshield, install right igniter in its well in diffuser case. Tighten with a wrench to torque of 300 - 360 pound-inches.

(2) Install left igniter in same manner.

IGNITER PLUGS - ADJUSTMENT/TEST

1. Igniter Plug

A. Test

(1) General

CAUTION: IT MAY BE NECESSARY TO REPLACE IGNITER PLUG, IF DROPPED, BECAUSE OF INTERNAL DAMAGE.

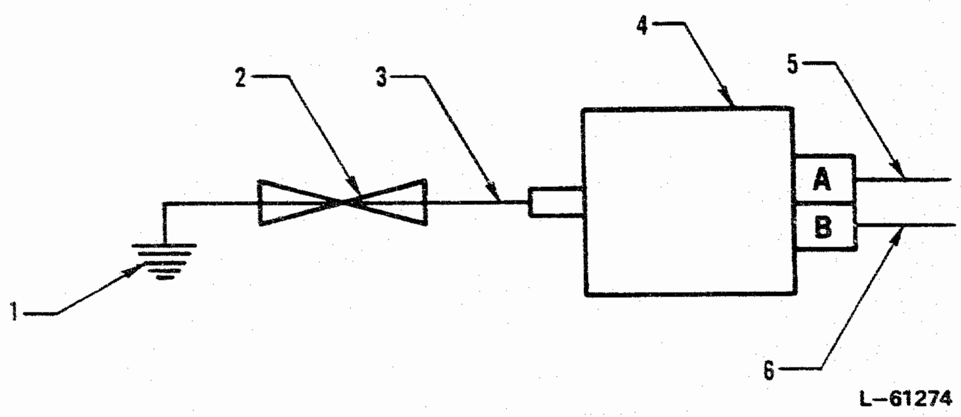
(a) Use System I (Boeing) or System II (Douglas) ignition equipment for test.

(2) Procedure
See Figure 501.

(a) Connect test equipment and igniter plug per Figure 501.

WARNING: BECAUSE SYSTEM VOLTAGE IS DANGEROUSLY HIGH, IGNITION SYSTEM MUST BE INOPERATIVE FOR SEVERAL MINUTES BEFORE REMOVAL OF IGNITER PLUG.

(b) Compare consistency and intensity of igniter spark with new or good igniter plug.



1. Ground
2. Igniter Plug
3. Ignition Cable
4. Ignition Exciter (20 Joule)
5. Ground For System I, 28VDC; Or System II 115V, 400HZ
6. Positive For System I, 28VDC; Or System II 115V, 400HZ

Test Setup
Figure 501

IGNITER PLUGS - INSPECTION/CHECK

1. Igniter Plug - Inspection

A. See Figures 601, 602, 603, and 604.

CAUTION: IT MAY BE NECESSARY TO REPLACE IGNITER PLUG IF DROPPED BECAUSE OF INTERNAL DAMAGE.

(1) Dimensionally inspect wear of plug using lighted magnifying glass looking at firing end (17, Figure 602) annulus to determine if tip insulator (15) supporting shoulder is worn through. See Figure 601. Wear of Champion Igniter Plug(s) may be measured using wear service tool CT-492 (formerly CT-468). Tool is available from Champion Spark Plug Company, 900 Upton Avenue, Toledo, OH 43601 U.S.A.

NOTE: Visual determination of excessive wear is presently only practical means of evaluating plug wear. Maximum outer shell ID erosion is a physical limit to prevent possible loss of ceramic cracking and internal firing. When excessively eroded, the ceramic can be ingested by the turbine.

Although igniter plugs will continue to fire after exceeding erosion limits, the voltage required to achieve a spark is increased to a level which can stress other ignition system components, particularly the high tension lead.

(2) Visually inspect shell threads (5, Figure 602) and coupling thread (8) for damage. If damaged, chase threads using 1.000-20NS-3A for coupling thread and 0.9375-16NS die for shell thread.

(3) Inspect ceramic for cracks on either end of plug. Any cracks in ceramic are unacceptable. Internal ceramic breaks are detected by shaking plug and listening for rattle.

(4) Inspect igniter plug as shown in Figure 602 for wear. Plugs not meeting required wear limits are unacceptable.

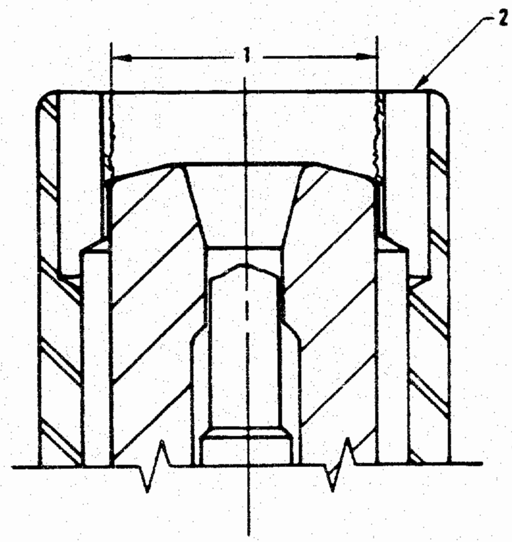
(5) Visually inspect ceramic recess (9) as follows:

(a) Presence of oil, dirt or conductive contaminants. Clean per Cleaning.

(b) Evidence of arcing at terminal button (10). Arcing is identified by pitting or discoloration of button. See Figure 603.

1 Minor pitting or discoloration may be cleaned per Cleaning.

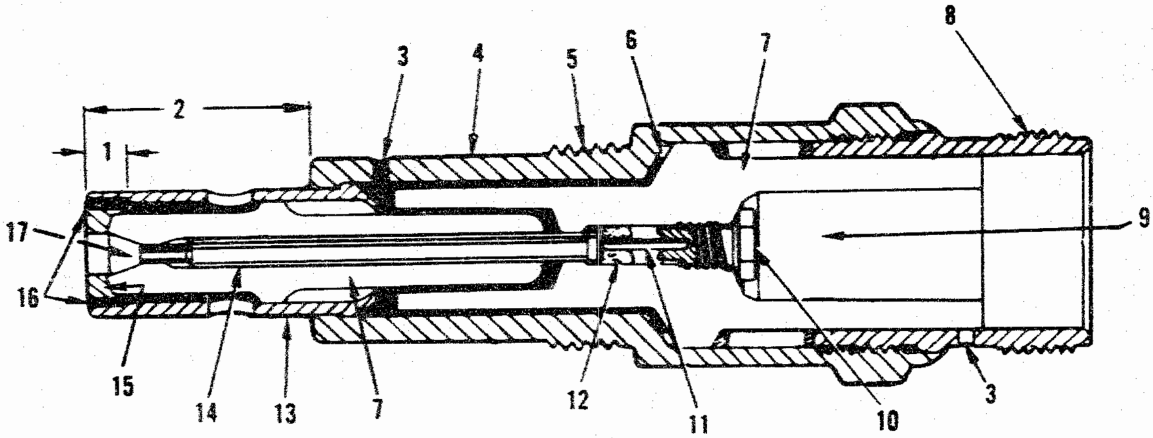
IGNITER PLUGS - INSPECTION/CHECK



1. 0.325 Inch Maximum Tip Shell Erosion
2. Air Cooling Holes

Igniter Plug ID Erosion Limit
Figure 601

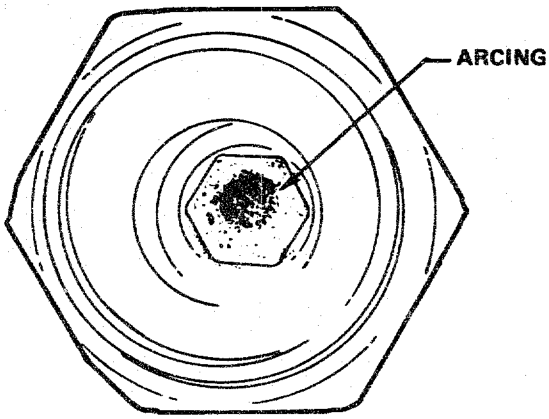
IGNITER PLUGS - INSPECTION/CHECK



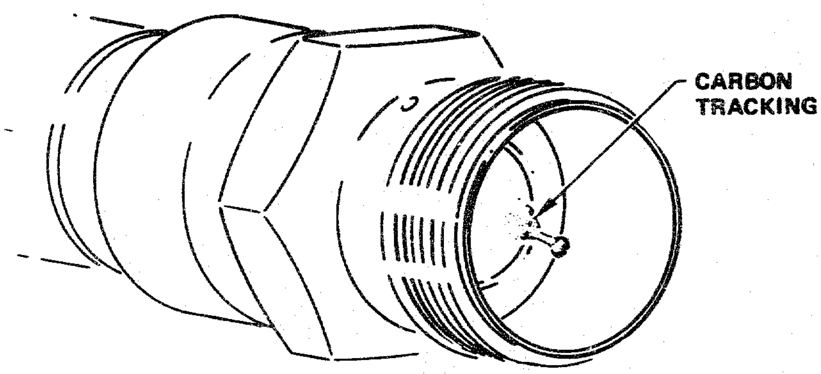
R 1. Wear Depth In This Area Should Be Carefully Checked To Make Sure No Small Pieces Could Liberate And Fall Into Engine.
R 2. Depth Of Barrel Wear Shall Not Exceed 0.030 Inch (0.762 mm) Or Intersect With Any Cooling Holes For Dry And Wet Igniter Plug With Welded Shield. For Wet Fluted Igniter Plug, Depth Of Wear Shall Not Exceed 0.030 Inch (0.762 mm).
3. Condensation Drain Hole
4. Main Shell
5. Shell Thread
6. Gasket
7. Ceramic Insulator
8. Coupling Thread
9. Ceramic Recess
10. Terminal Button
11. Sealing Wire
12. Cement
13. Tip Shell
14. Center Electrode
15. Tip Insulator
16. Air Cooling Holes
17. Firing End

Inspection And Wear Limits
Figure 602

IGNITER PLUGS - INSPECTION/CHECK



Arcing On Terminal Button
Figure 603



Flashover On Ceramic Insulator
Figure 604

IGNITER PLUGS - INSPECTION/CHECK

2 If arcing causes excessive terminal button erosion, send plug to repair facility.

(c) Evidence of flashover on ceramic insulator. Flashover is identified by carbon tracking. See Figure 604.

1 If carbon track is evident send plug to repair facility.

IGNITER PLUGS - CLEANING/PAINTING

1. Cleaning Igniter Plug

CAUTION: IT MAY BE NECESSARY TO REPLACE IGNITER PLUG IF DROPPED BECAUSE OF INTERNAL DAMAGE.

A. Using wire bristle brush and PMC 9056 solvent, remove foreign deposits from main and tip shells. Wipe with clean lint-free cloth.

B. Using cotton tipped applicator dampened with PMC 9056 solvent, clean ceramic recess and ceramic at firing end of plug.

CAUTION: ENSURE CONDENSATION DRAIN HOLES AND COOLING AIR HOLES ARE FREE FROM FOREIGN PARTICLES. BLOCKAGE OF DRAIN HOLES COULD CAUSE CERAMIC CRACKING OR PLUG SHORTING. CLOGGED COOLING AIR HOLES WILL REDUCE EFFECT OF COOLING.

NOTE: It is not necessary to restore ceramic to cleanliness of new plug. Clean recessed center of firing end of plug only to extent that ceramic is visible for inspection.

C. Remove all traces of solvent using clean compressed air maintained at 30 psig maximum pressure.

D. Clean minor pitting or discoloration of terminal button as follows:

(1) Insert rubberized abrasive rod (0.50 inch diameter, 4.000 inches length) in ceramic recess making contact with terminal button.

NOTE: Rubberized abrasive rod is available from Cratex Manufacturing Company, Burlingame, CA 94010 U.S.A.

(2) With circular movement of rod, remove suface imperfections or discoloration.

(3) Remove any residue using dry, clean, compressed air maintained at 30 psig maximum discharge pressure.

LIST OF EFFECTIVE PAGES

Please insert the revised pages into this manual and delete obsoleted pages in accordance with the following List of Effective Pages. Revised pages are indicated by the letter "R", added pages by the letter "A", and deleted pages by the letter "D". Superseded pages shall be removed and destroyed.

The List of Effective Pages records not only each page of subject revision but also each previously issued page which is still current. Blank pages and pages which are no longer current do not appear on this list. If there is any question about the currency of the recipient's copy, it is recommended that each page of the manual be checked off against this List of Effective Pages. Any page which does not check out with this list, either by number or by date, shall be discarded.

TABLE OF CONTENTS

TABLE OF CONTENTS

AIR - DESCRIPTION AND OPERATION

ENGINE ANTI-ICING SYSTEM

General

The engine anti-icing air system consists of temperature regulators, valves, tubing and internal passages for the transmission of hot compressed air through the compressor inlet guide vane and shroud weldment.

Description and Operation

Hot compressed air is picked up from the diffuser case. Two systems are used for transmittal of this air, one on each side of the engine. Except for the shape of the tubes, the systems are identical. Air moves forward through the steel tubes to a temperature regulator valve, through an air shut-off valve, then through more tubes and is discharged into the outer shroud ring of the inlet guide vane and shroud weldment. From the hollow space between the two walls of the outer shroud, the air passes inward through the leading and trailing edges of each inlet guide vane. From the guide vanes the air passes into the space between the walls of the inner shroud. From here the air passes out the forward edge of the shroud and dumps to the inner front edge of the engine inlet.

AIR - DESCRIPTION AND OPERATION

FUEL DE-ICING AIR SYSTEM

Description

The fuel de-icing air system consists of diffuser-case-to-air-shutoff-valve tubing, the shutoff valve, the air side of the fuel de-icing heater, and an airframe supplied tube used to vent the air overboard.

Operation

Actuation of a cockpit switch opens the air shutoff valve and permits hot air from the diffuser case to pass through the tubes in fuel de-icing heater core. Fuel flowing through the heater is warmed by contacting the outside of these tubes and then passes on to perform its function of de-icing the filter.

AIR - DESCRIPTION AND OPERATION

COMPRESSOR BLEED SYSTEM

General

The compressor bleed system is designed to relieve the engine of excess air when it is not needed. Except during normal operating thrust and higher, the engine does not need the full output of both compressors. When cranking first begins, air will flow inward through the compressor bleed valve to the inlet of the rear compressor. This relieves part of the windmilling load of the front compressor. By the time the engine starts, the second, third and fourth stage turbines will be driving the front compressor. Air will then be coming out of the compressor bleed valve.

The bleed valve is left open after starting to give good acceleration characteristics to the engine. When the power lever is advanced, the added energy from the increased fuel burned is used to accelerate the rear compressor. This unit has lower inertia than the front compressor being lighter and smaller in diameter. As the rear compressor picks up speed, air flow through the combustion chambers increases rapidly. More and more fuel can be burned. The exhaust from the first stage of the turbine will gradually increase the speed of the remaining stages. The front compressor will slowly increase speed. At approximately 88% N_2 speed the air bleed valve closes, and will remain closed until speed is reduced. If this engine had no air bleed system, the fuel schedule would have to be slowed to allow the heavy front compressor to pick up speed in step with the rear compressor. The time lapse from idle to maximum thrust would be longer.

Deceleration is also aided by the compressor bleed valve. By having the valve open at a point just below normal operating speeds, it is possible to relieve some of the air flow from the front compressor. This will allow the fuel schedule to drop as rapidly as the lighter rear compressor slows down.

There are two types of bleed systems used on JT3D engines; the pressure ratio bleed system and the temperature biased bleed system. Descriptions of each follow.

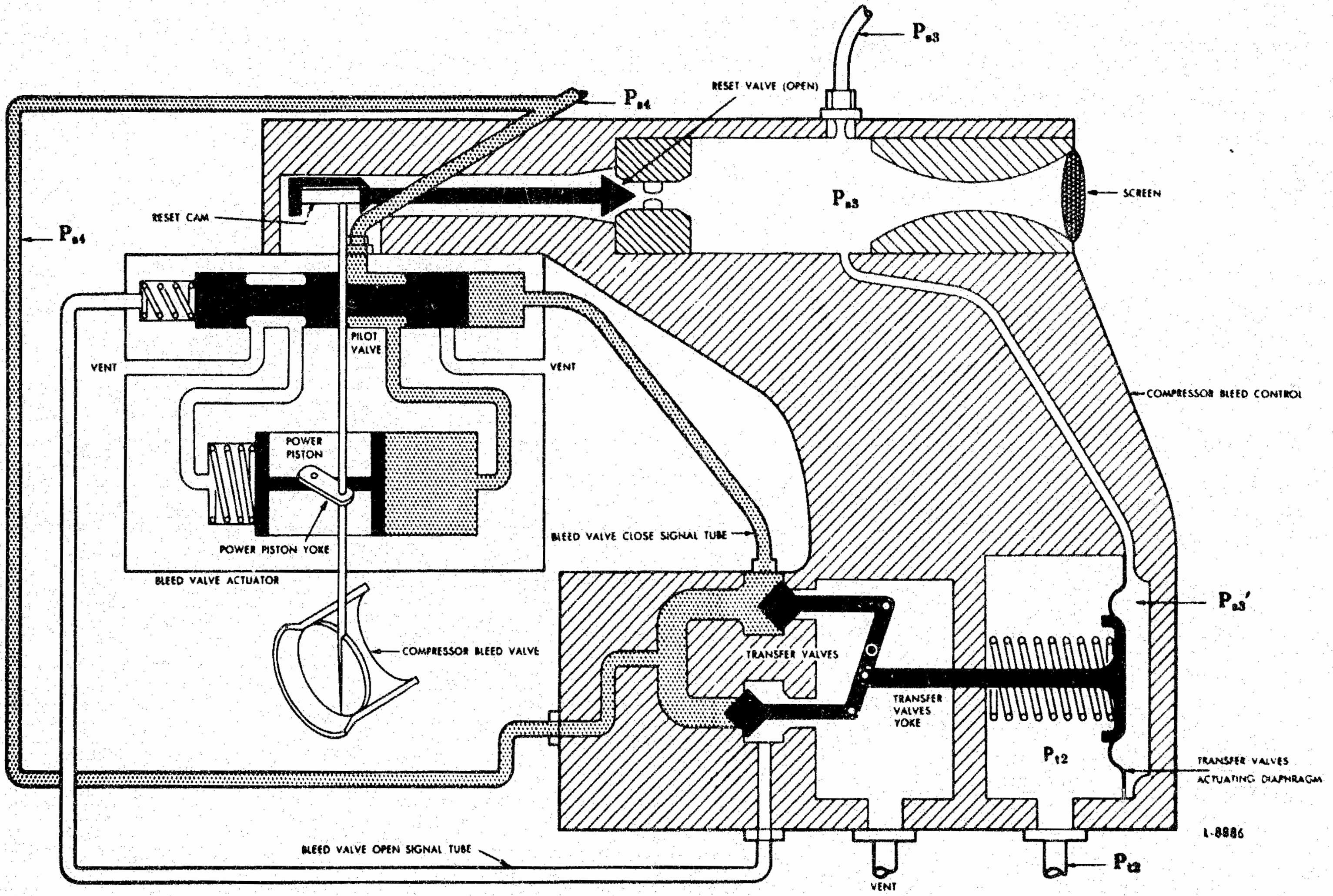
Pressure Ratio Bleed System - Description

See Figure 1.

The pressure ratio bleed system consists of a bleed valve to which is attached an actuator control which functions under the influence of differential air pressure.

Pressure Ratio Bleed System - Operation

The pressure ratio bleed control schedules bleed valve operation to a varying front compressor pressure ratio; the total pressure at the front compressor inlet (P_{t2}) to the pressure at the front compressor discharge (P_{s3}). This ratio varies as a function of the P_{t2}/P_{s3} relationship.



Pressure Ratio Compressor Bleed System Schematic
Figure 1

AIR - DESCRIPTION AND OPERATION

COMPRESSOR BLEED SYSTEM

The front compressor discharge pressure (P_{s3}) is used to achieve an intermediate high discharge pressure (P_{s3}'). This is accomplished by means of a dual orifice system within the control. A constant pressure ratio ($P_{t2}/P_{s3'}$) can be obtained between the inlet and intermediate low pressures. This ratio varies as the intermediate pressure varies. The intermediate low pressure ($P_{s3'}$) is induced to the high pressure side of a diaphragm. The low pressure (P_{t2}) is induced to the low pressure side of this diaphragm. With the help of a springs force to P_{t2}, a balance is obtained between P_{t2} and $P_{s3'}$. Any deviation from the null position produces a corrective action by varying the low pressure bleed valve.

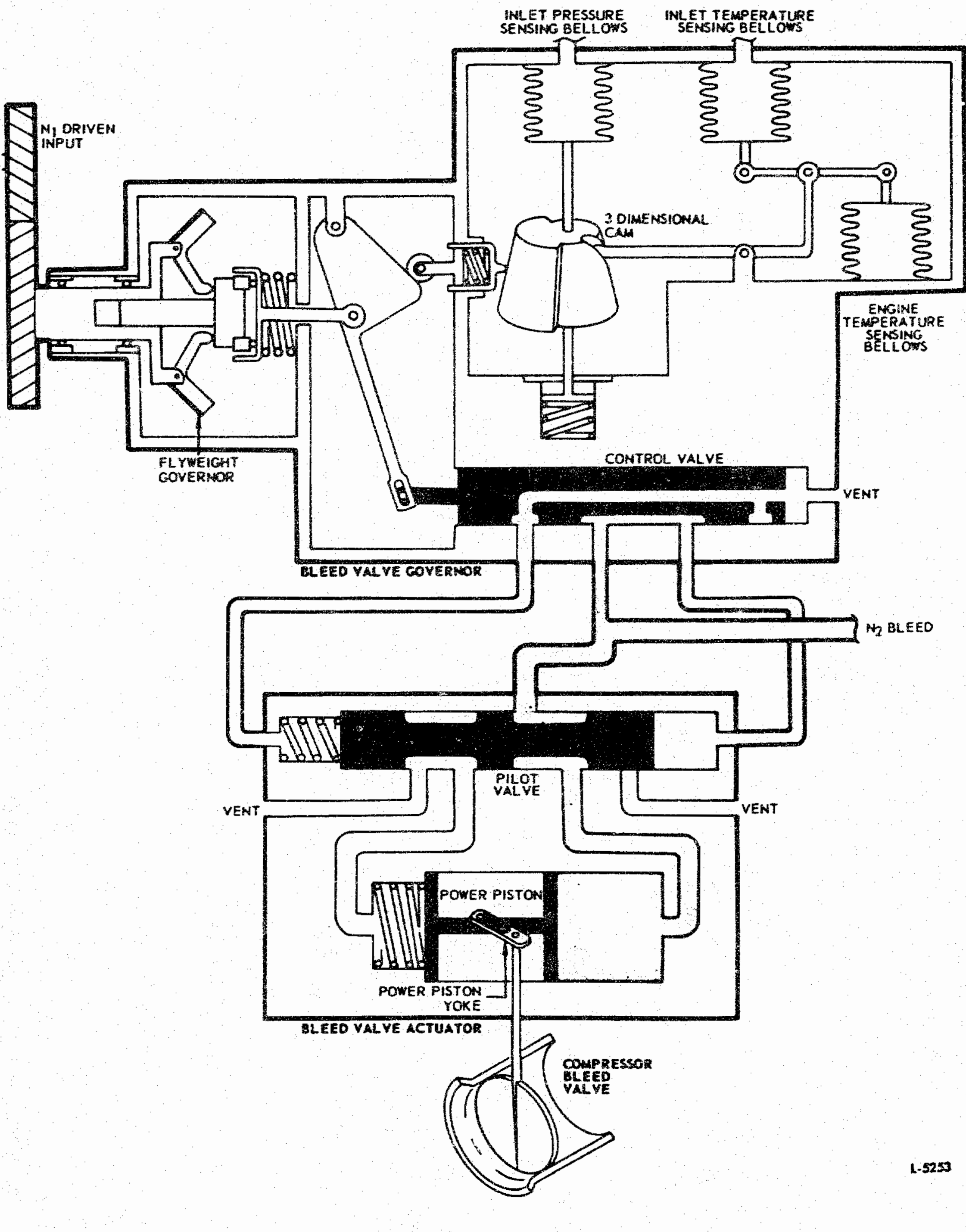
The displacement output resulting from a control deviation from the balanced position is mechanically transmitted through a yoke assembly to a transfer valve assembly. The transfer valve assembly consists of two poppet-type transfer valves whose function is to transmit the desired signal pressure to the bleed valve actuator assembly to schedule either open or closed bleed valve positions. Engine rear (high) compressor discharge air (P_{s4}) is always supplied to one end of each poppet valve and ambient pressure to the other end. Therefore, depending on the direction of the control signal, the transfer valves will be scheduled either in the bleed open or bleed closed position and the rear (high) compressor discharge air will be directed through the transfer valve to either the open or closed signal line to the bleed valve and actuator.

A reset feature is designed into the control to accommodate the step change in rear (high) compressor engine pressure between bleed closed and bleed open. The reset is necessary because there is an appreciable change in engine front (low) compressor discharge pressure between the bleed open and bleed closed positions and if this was not compensated, excessive hysteresis in the control would occur. The reset mechanism is a mechanical feedback system from the bleed valve such that when the bleed valve is in the closed position, the reset valve will be open and conversely, when the bleed valve is in the open position, the reset valve will be in the closed position.

Temperature Biased Bleed System - Description

See Figure 2.

The temperature biased bleed system consists of a bleed valve to which a bleed actuator control is attached, a bleed control which is mounted on the front compressor accessory drive pad, and the necessary connecting tubing. The bleed control schedules bleed valve operation in relation to front compressor rotational speed, inlet temperature, and inlet pressure.



Temperature Biased
Compressor Bleed System Schematic

Figure 2

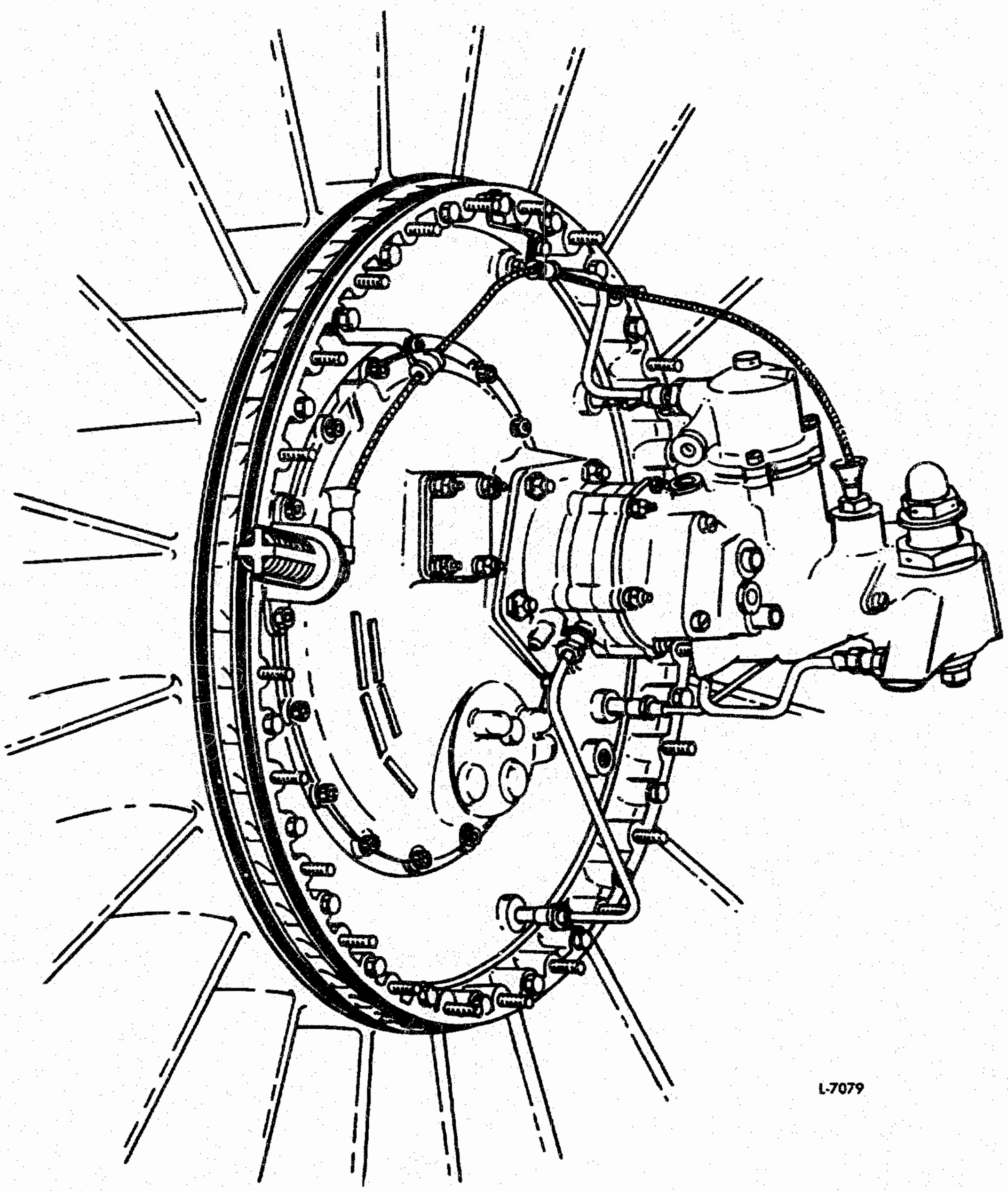
AIR - DESCRIPTION AND OPERATION

COMPRESSOR BLEED SYSTEM

Temperature Biased Bleed System - Operation

The bleed valve is a butterfly valve located near the rear of the compressor intermediate case at the eight o'clock position. Air that passes through the valve travels from the front compressor inside of the intermediate case but outside of the rear compressor case. The bleed actuator control is bolted to and supported by two studs located in the bleed valve body on the pad from which the bleed valve shaft protrudes. The bleed actuator control contains an air operated piston and pilot valve, the piston operating the bleed valve shaft through a slotted arm.

The bleed control (governor) (see Figure 3) is mounted on the front accessory case. This is the unit that controls the bleed valve actuator control. There are three input signals to the actuator control. The speed of the front compressor (N_1), is the basic signal, and is obtained by a gear drive through the front accessory drive gear. The remaining two signals, inlet total air temperature (T_{t2}), and pressure (P_{t2}), are used to modify the basic speed signal. The temperature signal is picked up by a thermostatic bulb which is located on the engine inlet guide vane and shroud assembly. The pressure signal is picked up by a probe in the same assembly. The probe is mounted on the outer wall of the inner shroud. Tubing connects the probe to the control.



Compressor Bleed Control

Figure 3

AIR - TROUBLESHOOTING

1. Engine Anti-Icing System

   A. Refer to Section 72-0, Engine - Troubleshooting.

2. Fuel De-Icing Air System

   A. Refer to Section 72-0, Engine - Troubleshooting.

3. Compressor Bleed System

   A. Refer to Section 72-0, Engine - Troubleshooting.

AIR - MAINTENANCE PRACTICES

ANTI-ICING AIR SYSTEM

1. Periodic Inspection

A. General

(1) These inspection procedures are a normal function of operating organizations. They consist of required inspections and minor adjustments necessary on the engine. The nature and conditions of engine operation determine the time interval between required inspections. For this reason the intervals described in the Periodic Inspection Chart in this section are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because the extensive mass air flow tends to draw foreign objects into the engine. Thoroughly clean the entire engine compartment with a vacuum cleaner after completion of any work. Keep the compartment free of dirt, oil and grease, and remove any small unused parts, such as nuts, washers, and pieces of lockwire. Immediately cover all apertures resulting from the disconnection of tubing or parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect the exterior of the engine without dismantling to ensure that all connections are tight and free from leaks and that lines, tubing, and controls are secure and properly locked.

B. Periodic Inspection Chart

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
Shut-Off Valves	Operation of Shut-Off Valves	X		

2. Removal/Installation of the Anti-Icing Tubes (JT3D-1 Douglas, JT3D-3 Douglas, JT3D-3B Douglas)

NOTE: Observe and mark the positions of all clips and brackets so that they may be properly installed during reassembly.

AIR - MAINTENANCE PRACTICES

ANTI-ICING AIR SYSTEM

A. Anti-Icing Air System - Removal (JT3D-1 Boeing JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6, and JT3D-1-MC7)

(1) Remove the bolts securing the left front anti-icing tube to the lower left side of the front compressor front case (case and vane assembly). Remove the bolt securing this tube at the top to the front flange of the inlet case.

(2) Unfasten the locknut and bolt and remove the gasket, spacer, and coupling assembly from the rear of the tube. Remove the tube from the engine.

(3) Remove the bolts and the cover from the other pad on the left side of the front compressor front case.

(4) Remove the bolts securing the right front anti-icing tube to the lower right side of the front compressor front case and the bolt securing it at the top to the front flange of the inlet case.

(5) Unfasten the locknut and bolt and remove the gasket, spacer, and coupling assembly from the rear of the tube. Remove the tube from the engine.

(6) Remove the bolts and the cover from the other pad on the right side of the front compressor front case.

(7) Unfasten the locknuts and bolts and remove the details and the two coupling assemblies at the branches of the left anti-icing manifold. Remove the left intermediate and right intermediate anti-icing tubes from the top of the engine.

(8) Remove the bolts and locknuts securing the left anti-icing manifold assembly to the bracket located on the upper left quadrant of the middle flange of the front compressor rear case.

(9) Unfasten the bolts securing the left anti-icing regulator and valve assemblies to the left rear anti-icing tube and remove the left anti-icing manifold assembly and the left regulator and valve assemblies from the engine.

(10) Unfasten the bolts securing the bracket and remove the bracket from the front compressor case. Tag or note the location of the bracket to ensure its proper position at assembly.

(11) Unfasten the bolts securing the left rear anti-icing tube to the center left side of the diffuser case and remove the tube.

AIR - MAINTENANCE PRACTICES

ANTI-ICING AIR SYSTEM

(12) Unfasten and remove the bolts securing the anti-icing connector to the top of the front compressor front case.

(13) Rotate the connector to unlock it from the right upper anti-icing tube and remove the connector.

(14) Remove the bolts securing the right upper anti-icing tube to the right anti-icing regulator, bracket, rear tube, and valve assemblies and remove the tube and the right anti-icing regulator and valve assemblies from the engine.

(15) Unfasten the bolts securing the right rear anti-icing tube to the upper right side of the diffuser case and remove the tube.

B. Anti-Icing Air System-Removal (JT3D-1 Douglas, JT3D-3 Douglas, and JT3D-3B Douglas)

NOTE: See Paragraph C. for JT3D-3B-DL engines.

(1) Remove the bolts securing the right front anti-icing tube to the lower right side of the front compressor front case (case and vane assembly). Rotate the tube to unlock it from the right anti-icing regulator outlet manifold and remove the tube from the engine.

(2) Unfasten the bolts securing the right anti-icing regulator outlet manifold to the port on the upper right side of the front compressor front case and to the flanges of the right regulator and regulator housing and remove the manifold.

(3) Remove the bolts securing the right anti-icing regulator housing to the bracket located on the upper right side of the rear flange of the front compressor front case. Rotate the housing to unlock it from the right anti-icing manifold assembly and remove the housing and the regulator from the engine.

(4) Unfasten the bolts securing the bracket and remove the bracket from the engine. Tag or note the location of the bracket to ensure its proper position at assembly.

(5) Remove the bolts securing the right anti-icing manifold to the anti-icing valve assembly and bracket. Remove the manifold and the bracket from the engine.

(6) Unfasten and remove the bolts securing the anti-icing valve assembly to the right rear anti-icing tube. Remove the valve assembly from the engine.

AIR - MAINTENANCE PRACTICES

ANTI-ICING AIR SYSTEM

(7) Unfasten the bolts securing the right rear anti-icing tube to the upper right side of the diffuser case and remove the tube from the engine.

(8) Remove the bolts securing the left front anti-icing tube to the lower left side of the front compressor front case (case and vane assembly); then rotate the tube and remove it from the engine.

(9) Remove the bolts securing the left anti-icing regulator outlet manifold to the port on the upper left side of the front compressor front case and to the flanges of the left regulator and regulator housing and remove the manifold.

(10) Unfasten the bolts securing the regulator housing to the bracket on the upper left side of the rear flange of the front compressor front case. Rotate the housing to unlock it from the left front anti-icing manifold and remove the housing and the regulator from the engine.

(11) Remove the bolts securing the left front anti-icing manifold to the left anti-icing valve assembly and to the bracket on the front compressor rear case and remove the manifold from the engine.

(12) Remove the bolts securing the left rear anti-icing manifold to the valve assembly and bracket, and to the valve assembly. Remove the valve assembly and discard the gasket. Remove the bolts securing the left rear anti-icing manifold to the lower left side of the diffuser case, and remove the manifold.

(13) Remove bolts and cover from left rear anti-icing manifold branch tube.

(14) Remove bracket from front compressor rear case. Tag or note its location to ensure its proper position at assembly.

C. Anti-Icing System-Removal (JT3D-3B-DL)

(1) Remove clip bolt and nut securing anti-icing right manifold to front flange of front compressor front case. Then remove bolts securing anti-icing right manifold to lower and upper pads on front compressor front case and the bolts securing manifold to valve and actuator assembly on anti-icing front manifold. Remove right manifold and gaskets from engine.

(2) Remove clip bolt and nut securing anti-icing left manifold to front flange of front compressor front case. Then remove bolts securing anti-icing left manifold to lower and upper pads on front compressor front case and the bolts securing manifold to valve and actuator assembly on anti-icing front manifold. Remove left manifold and gaskets from engine.

AIR - MAINTENANCE PRACTICES

ANTI-ICING AIR SYSTEM

(3) Unfasten bolt and locknut of coupling connecting anti-icing front manifold to intermediate tube and remove coupling, front manifold and regulators and valve assemblies from engine.

(4) Remove the two bolts and nuts securing anti-icing intermediate tube to bracket on front flange of diffuser case and then unfasten coupling bolt and locknut to remove coupling, intermediate tube and gasket.

(5) Remove bolts securing anti-icing rear manifold to pads on right and left sides of diffuser case and remove rear manifold and gaskets from engine.

D. Anti-Icing Air System-Installation (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7)

See Figure 201 and 202.

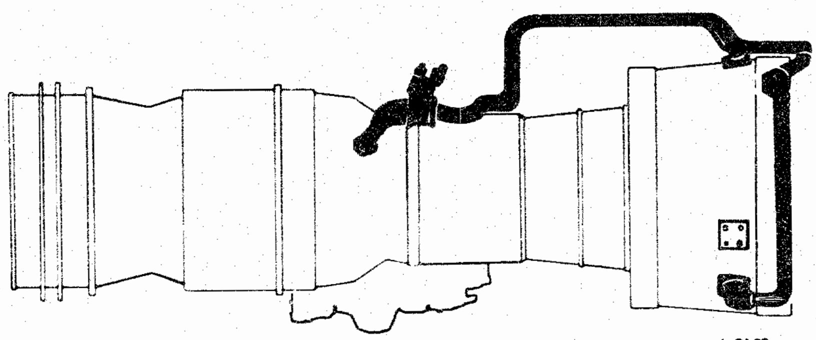
(1) Place new gasket on pad of upper right side anti-icing port on diffuser case and install right rear anti-icing tube, securing tube to case with bolts. Torque and lockwire bolts.

(2) Place new gasket on the front flange of the right rear anti-icing tube and insert the anti-icing air regulator assembly into the tube.

(3) Place new gasket on rear flange of right intermediate anti-icing tube and with tube on bench, position flange of anti-icing air valve on rear flange of right anti-icing tube so that electrical connection on valve will be toward front and facing upward when installed on engine.

NOTE: On configuration incorporating anti-icing air valve having four holes in front and rear flange, secure the air valve and gasket to rear flange of right intermediate anti-icing tube with the two upper short bolts and nuts. Position boltheads against flange of air valve.

(4) For configuration incorporating valve and regulator assemblies having six holes in mounting flanges, install four upper bolts which attach right upper anti-icing tube to anti-icing air valve and place gasket on rear flange of air valve; then position this assembly on anti-icing regulator assembly. Insert two longer bolts through bracket on intermediate case and through bottom holes of flanges of tubes and valves. Secure six bolts to flange of rear anti-icing tube with locknuts. Torque locknuts.

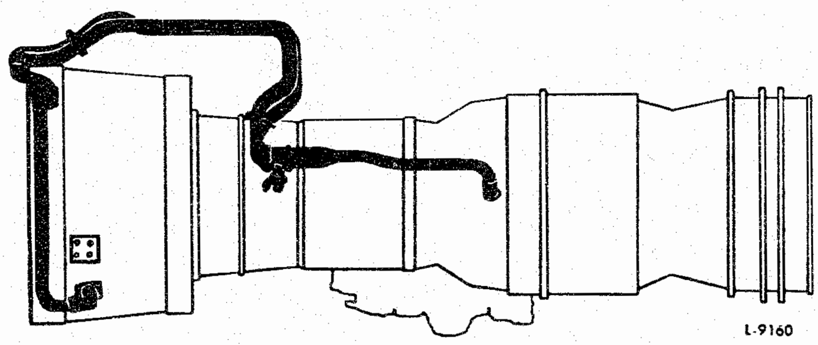


Anti-Icing Air System-Right Side
(JT3D-1 Boeing, D-3 Boeing, D-3B Boeing,
MC-6 and MC-7)
Figure 201

(5) For configuration incorporating anti-icing air valve and regulator assemblies having four holes in mounting flanges, place gasket on rear flange of air valve and then position this assembly on anti-icing regulator assembly. Insert two long bolts through bracket on intermediate case and through flanges of tubes and valves. Install nuts on long bolts and secure top rear flange of air valve to regulator and rear tube with short bolts and nuts. Torque and lockwire nuts.

NOTE: Optional solenoid actuated air shutoff actuator and valve, PN 730071, used in some Boeing installations, is interchangeable with electric motor driven air shutoff Actuator and Valve, PN 586804.

(6) For configuration incorporating short anti-icing front tube and one piece coupling, slip coupling over front of anti-icing intermediate tube and then install anti-icing front tube on intermediate tube; locking it in position by rotating. Position coupling over junction of two tubes and clamp in place with bolts and nut. Torque nut.



Anti-Icing Air System - Left Side
(JT3D-1 Boeing, D-3 Boeing, D-3B Boeing,
MC-6 and MC-7)
Figure 202

AIR - MAINTENANCE PRACTICES

ANTI-ICING AIR SYSTEM

(7) For configuration incorporating long anti-icing front tube and hinge type coupling, position anti-icing front tube on intermediate tube with coupling gasket positioned between tubes. Place coupling over junction of two tubes and secure in place with bolt, spacer and nut. Torque nut.

(8) Install gasket on pad on top of front compressor front case, (case and vane assembly) and bolt anti-icing connector to pad. Tighten bolts to recommended torque and lockwire.

(9) Place new gasket on pad at center of left side of diffuser case and install left rear anti-icing tube, securing tube to case with bolts. Torque and lockwire bolts.

(10) Place new gasket on front flange of left rear anti-icing tube and insert anti-icing air regulator assembly into tube.

(11) Place new gasket on flange of regulator assembly and position flange of anti-icing air valve on flange of regulator assembly so that electrical connection on air valve will be toward front and facing downward. Support air valve in this position.

(12) Place new gasket on front flange of air valve and while still supporting air valve, install left anti-icing manifold to front flange of air valve. Secure manifold to air valve by installing bolts through flanges of rear tube and valve assemblies. Torque and lockwire bolts.

(13) Bolt left anti-icing manifold assembly to bracket on upper left quadrant of middle flange of front compressor rear case and secure with locknuts tightened to recommended torque.

(14) Position left intermediate and right intermediate anti-icing tubes on top of engine and to branches of left manifold.

(15) Connect tubes with gasket, spacer, and coupling assembly to each branch of left manifold. Install bolt, spacer, and locknut in each coupling assembly and tighten locknuts to recommended torque.

(16) Install left front anti-icing tube to mating intermediate anti-icing tube and around left side of engine.

(17) Connect intermediate tube to front tube with gasket, spacer, and coupling assembly. Install bolt, spacer, and locknut in coupling assembly and torque locknut.

(18) Install new gasket on lower pad on lower left side of front compressor front case and bolt front tube flange to pad. At upper elbow of tube bolt it to flange of the inlet case. Torque and lockwire all tube holding bolts.

(19) Place new gasket and cover over other left side pad; install bolts; then tighten them to recommended torque and lockwire.

(20) Install right front anti-icing tube to mating intermediate anti-icing tube and around the right side of engine.

(21) Connect right intermediate tube to its front tube with gasket, spacer, and coupling assembly. Install bolt, spacer, and locknut in coupling assembly and tighten locknut to recommended torque.

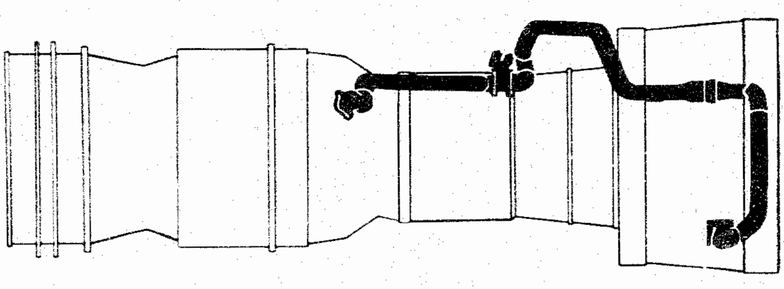
(22) Install new gasket on lower pad on lower right side of front compressor front case and bolt front tube flange to pad. At upper elbow of tube bolt it to front flange of inlet case. Torque and lockwire tube holding bolts.

(23) Place new gasket and cover over other right side pad; then install the bolts. Torque and lockwire.

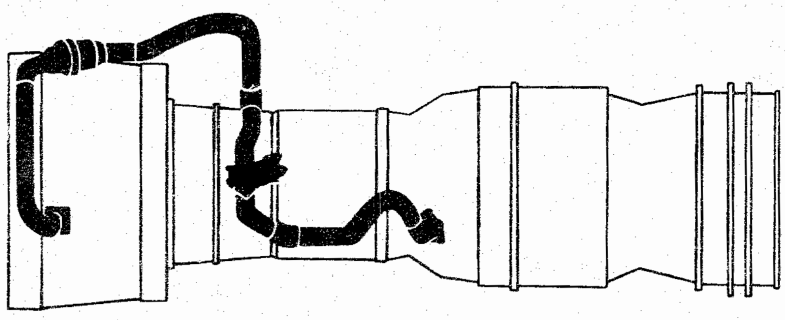
E. Anti-Icing Air System-Installation JT3D-1 Douglas, JT3D-3 Douglas and JT3D-3B Douglas)

See Figures 203 and 204.

NOTE: See Paragraph F. for JT3D-3B-DL Engine.



Anti-Icing Air System - Right Side
(JT3D-1 Douglas, D-3 Douglas,
and D-3B Douglas)
Figure 203



Anti-Icing Air System - Left Side
(JT3D-1 Douglas, D-3 Douglas,
and D-3B Douglas)
Figure 204

(1) Install left anti-icing valve bracket, with angle down, on mounting pad on left side of front compressor rear case. Torque bolts.

(2) Install new gasket and cover on short branch tube of left rear anti-icing manifold. Secure cover with bolts and locknuts. Torque locknuts.

(3) Place new packing on anti-icing port in lower left side of diffuser case and install left rear anti-icing manifold to case positioning manifold front end flange over anti-icing valve angle bracket. Secure with bolts. Torque and lockwire bolts.

(4) Place new gasket on left anti-icing valve assembly (lower flange).

(5) Position left anti-icing valve assembly on left rear anti-icing manifold so that electrical connection on valve is up and facing rearward. Secure anti-icing valve with four bolts through valve lower flange, bracket, and rear manifold upper flange. Install remaining two bolts. Torque locknuts.

(6) Place new gasket on upper flange of anti-icing valve and install left front anti-icing manifold to valve and bracket securing with bolts and locknuts tightened to recommended torque.

(7) Secure bracket on rear flange of front compressor front case at location noted at disassembly.

(8) Install left anti-icing regulator housing on front anti-icing manifold and rotate housing to lock it in position. Secure the housing to bracket with bolts and locknuts tightened to recommended torque.

(9) Place new gasket on flange of anti-icing regulator housing and insert regulator.

AIR - MAINTENANCE PRACTICES

ANTI-ICING AIR SYSTEM

(10) Place new gasket on flange of regulator and using new packing on port in front compressor front case, install left anti-icing regulator outlet manifold to flange of regulator and to upper left port. Secure flanges with bolts and locknuts tightened to recommended torque. Secure manifold to case with bolts tightened to recommended torque and lockwire.

(11) Install packing on anti-icing lower port on lower left side of front compressor front case.

(12) Install left front anti-icing tube into regulator outlet manifold and rotate tube to lock it in position. Secure tube to case at lower port with bolts. Torque and lockwire bolts.

(13) Place new gasket on anti-icing port on upper right side of diffuser case and install right rear anti-icing tube to case. Install bolts, torque and lockwire.

(14) Place new gasket on rear flange of right anti-icing valve assembly.

(15) Position right anti-icing valve assembly on right rear anti-icing tube so that electrical connection on valve is toward front and facing upward. Install bolts, torque locknuts.

(16) Place new gasket on front flange of right anti-icing valve assembly.

(17) Install bracket on rear flange of front compressor rear case. Secure manifold to valve and bracket with bolts and locknuts. Torque locknuts.

(18) Secure bracket on rear flange of front compressor front case at location noted at disassembly.

(19) Install right anti-icing regulator housing on right anti-icing manifold by rotating housing to lock it in position. Secure housing to bracket with bolts and locknuts. Torque bolts and locknuts.

(20) Place new gasket on flange of regulator housing and insert regulator.

(21) Place new gasket on flange of regulator and using new packing on port in front compressor front case, install right anti-icing regulator outlet manifold to flange of regulator and to upper right port. Secure flanges with bolts and locknuts tightened to recommended torque. Secure manifold to case with bolts. Torque and lockwire.

(22) Install packing on lower anti-icing port on lower right side of front compressor front case.

(23) Install right front anti-icing tube into regulator outlet manifold and rotate tube to lock it in position. Secure tube to case at lower port with bolts. Torque and lockwire.

F. Anti-Icing Air System-Installation (JT3D-3B-DL Engines)

(1) Place new gasket on upper right side anti-icing port and a gasket on anti-icing port at nine o'clock position on diffuser case. Install anti-icing rear manifold on these pads. Secure with bolts to required torque and lockwire.

(2) Install gaskets on upper and lowerpads on right side of fan case; then install right anti-icing air manifold on pads. Secure with bolts.

(3) Install gaskets on upper and lower pads on left side of fan case; then install left anti-icing air manifold on pads. Secure with bolts.

(4) Install anti-icing air regulator in each end of center anti-icing air manifold assembly; then install left and right anti-icing air shut-off valve and acutator assembly on each end of manifold and against regulator with actuator facing in same direction as connection for anti-icing rear tube assembly. Secure valve and actuator assemblies with bolts and locknuts.

(5) Install parts assembled in step (4) between right and left anti-icing air manifolds, with actuators pointing rearward. Secure assembly to brackets at front flange of fan case with bolts washers and nuts. Tighten to recommended torque.

NOTE: Boltheads to face rearward with flat washer against bolthead and bracket and shouldered washer between bracket and manifold assembly.

(6) Secure center manifold assembly to right and left manifold assembly with bolts and locknuts. Tighten nuts securing left and right anti-icing air manifolds to recommended torque. Tighten nuts securing center manifold to right and left manifolds to recommended torque. Lockwire bolts securing right and left manifold assemblies to fan case.

(7) Install coupling gasket to each end of anti-icing rear tube; then install tube against upper manifold assembly and to the intermediate case rear flange bracket at approximate 11 o'clock position. Secure flange of tube against forward face of bracket with screws, flat washers, shouldered washers, and locknuts. Tighten to recommended torque.

NOTE: Shouldered washers shall be installed between bracket and tube and flat washer against nut and bracket.

PN 452205 bracket assembly has been replaced by PN 765557 bracket assembly.

AIR - MAINTENANCE PRACTICES

ANTI-ICING AIR SYSTEM

(8) Secure clamp coupling at both ends of anti-icing rear tube with bolts, washers, and nuts. Torque nuts.

(9) Install cover gasket and cover on remaining pad on right side of center anti-icing air manifold assembly. Secure with bolts and nuts to recommended torque.

AIR - MAINTENANCE PRACTICES

FUEL DE-ICING AIR SYSTEM

1. Periodic Inspection

A. General

(1) These inspection procedures are a normal function of operating organizations. They consist of required inspections and minor adjustments necessary on the engine. The nature and conditions of engine operations determine the time interval between required inspection. For this reason, the intervals described in the periodic inspection chart in this section are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because the extensive mass air flow tends to draw foreign objects into the engine. Thoroughly clean the entire compartment with a vacuum cleaner after completion of any work. Keep the compartment free of dirt, oil and grease, and remove any small unused parts, such as nuts, washers, and pieces of lockwire. Immediately cover all apertures resulting from the disconnection of tubing or parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect the exterior of the engine without dismantling to ensure that all connections are tight and free from leaks and that lines, tubing, and controls are secured and properly locked.

B. Periodic Inspection Chart

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
Fuel De-Icing Shut-Off Valve	Operation of Shut-Off Valves	X		

2. Removal/Installation of the Fuel De-icing Air Tubes (Optional Equipment)

NOTE: Tag or note the location of all clips to assure their installation in the same location at assembly.

AIR - MAINTENANCE PRACTICES

FUEL DE-ICING AIR SYSTEM

A. Removal

(1) Remove the screw and nut that secure the clips between the anti-icing air supply tube and the fuel de-icing air supply hose assembly. Remove the clips.

(2) Remove the bolts securing the fuel de-icing hose assembly rear adapter to the pad on the diffuser case lower left quadrant; then remove the bolts and nuts securing the hose assembly front adapter to the air shut-off valve located on the top of the heater assembly. Remove the hose assembly.

B. Installation

(1) Using new gaskets, position the air supply hose assembly to the pad in the left quadrant of the diffuser case and the air shut-off valve located at the top of the heater assembly. Secure the hose assembly to the diffuser pad with the bolts and to the air shut-off valve with the bolts and nuts. Tighten the bolts and the bolts and nuts to the recommended torque.

AIR - MAINTENANCE PRACTICES

COMPRESSOR BLEED SYSTEM

1. Periodic Inspection

A. General

(1) These inspection procedures are a normal function of operating organizations. They consist of required inspections and minor adjustments necessary on the engine. The nature and conditions of engine operations determine the time interval between required inspection. For this reason, the intervals described in the periodic inspection chart in this section are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because the extensive mass air flow tends to draw foreign objects into the engine. Thoroughly clean the entire compartment with a vacuum cleaner after completion of any work. Keep the compartment free of dirt, oil and grease, and remove any small unused parts, such as nuts, washers, and pieces of lockwire. Immediately cover all apertures resulting from the disconnection of tubing or parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect the exterior of the engine without dismantling to ensure that all connections are tight and free from leaks and that lines, tubing, and controls are secured and properly locked.

B. Periodic Inspection Chart

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
Compressor Bleed Valve and Actuator	a. Breaks or punctures of screen	X	X	X
	b. Actuator control for leaks and proper security.		X	X
	c. Check actuation. Note: Very effective for identifying corroded and sticking actuator assemblies.		X	X
	d. Actuator air supply filter and seals for security.		X	X
Bleed Control (Governor) (JT3D-1-MC6 and JT3D-1-MC7)	a. Security of mounting.		X	X
	b. Security of accessible lines and fittings.	X	X	X
	c. Security of temperature sensing element.		X	X
	d. Inspect for damage to capillary tube.		X	X

C. Compressor Bleed Valve

When checking the bleed valve operation or doing other work in, or adjacent to, the compressor bleed valve while the engine is running, care shall be taken to stand clear during bleed valve open operation.

WARNING: WHEN THE BLEED VALVE OPENS, HIGH PRESSURE AIR AT HIGH VELOCITY IS DUMPED OVERBOARD. EXPERIENCE HAS PROVEN THAT THE FORCE OF THIS AIR, PARTICULARLY WHEN THE VALVE FIRST OPENS DURING DECELERATION FROM HIGH RPM, IS SUFFICIENT TO TAKE A PERSON OFF HIS FEET RESULTING IN POSSIBLE INJURY.

AIR - MAINTENANCE PRACTICES

COMPRESSOR BLEED SYSTEM

2. Removal/Installation of the Compressor Bleed System Tubes

NOTE: Tag or note the location of all clips to make certain they are installed at the same location at assembly.

A. Bleed System Air Tubes - Removal (JT3D-1, JT3D-3, JT3D-3B and MC6 QANTAS)

NOTE: This procedure is also applicable for MC-6 Boeing and MC-7 engines with Pressure Ratio Bleed System.

(1) Remove all support clips.

(2) Unfasten the tube nuts at the bleed actuator control and at the screen housing assembly and remove the diffuser-to-bleed valve actuator control tube. Remove the connectors.

(3) Unbolt the screen housing assembly and remove the housing from the engine.

(4) Unfasten the tube nuts at the intermediate case and at the bleed actuator control and remove the intermediate case-to-bleed control pressure ratio tube. Remove the connectors.

(5) Unfasten the tube nuts at the inlet case and at the rear of the air sensing front tube and remove the air sensing front tube. Remove the connector from the inlet case.

(6) Unfasten the tube nut at the bleed actuator control assembly and remove the air sensing rear tube. Remove the connector from the bleed actuator control assembly.

(7) Unfasten the tube nuts at the bleed actuator control assembly and remove the actuator-to-control tubes from the control. Remove the connectors.

B. Bleed System Air Tubes - Removal (JT3D-1-MC6 and MC7 - Temperature Biased)

(1) Remove all support clips and clamps from the bleed system air tubes.

(2) Remove the diffuser-to-bleed valve actuator control tube.

(3) Unfasten the bolts securing the air screen housing to the diffuser case and remove the housing.

(4) Unfasten the connector nuts on the three actuator control-to-bleed control rear tubes and remove the tubes and the connectors.

AIR - MAINTENANCE PRACTICES

COMPRESSOR BLEED SYSTEM

(5) Unfasten the three actuator control-to-bleed control front tubes and remove the tubes and the connectors.

(6) Unfasten the tube nuts on the inlet air sensing tube on the inlet case and remove the tube and the connectors.

C. Bleed System Air Tubes - Installation (Except JT3D-1-MC6 and MC-7 - Temperature Biased System)

NOTE: See Paragraph D. for JT3D-3B-DL engines.

(1) Install new gaskets on air supply tube connectors; then screw them into their position in bleed actuator control assembly and tighten to the recommended torque.

(2) Fasten actuator to control tubes to connectors on bleed actuator control assembly. Torque and lockwire tube nuts.

(3) Install gasket under screen assembly; then install screen assembly into housing. Install connector on screen housing. Torque the connector 400 to 450 pound inches.

(4) Using new gasket, install screen housing on left side of diffuser case with bolts. Torque and lockwire bolts.

(5) Install new gasket on diffuser-to-compressor bleed air tube connector; then screw it into its position in bleed actuator control assembly. Tighten connector to recommended torque.

(6) Attach diffuser-to-compressor bleed air tube to connector on bleed actuator control and connector on screen housing. Torque tube nuts and lockwire. Install clip on tube and secure to bracket on front flange of diffuser case.

(7) Install new gasket on intermediate case-to-bleed control pressure ratio tube connector and screw connector into left side of intermediate case. Torque connector.

(8) Fasten intermediate case-to-bleed control pressure ratio tube to connector in intermediate case and to bleed actuator control.

(9) Install new seal on air sensing rear tube connector and screw connector into bleed actuator control. Torque connector.

(10) Fasten air sensing rear tube to connector at bleed actuator control and support forward end with clip assembly at intermediate case front flange. Torque nut at bleed actuator control.

AIR - MAINTENANCE PRACTICES

COMPRESSOR BLEED SYSTEM

(11) Install new seal on air sensing front tube connector and screw connector into inlet case. Torque connector.

(12) Fasten air sensing front tube to connector at inlet case and attach other end to air sensing rear tube. Torque tube nuts.

D. Bleed System Air Tubes - Installation (JT3D-3B-DL)

(1) Install gasket on connector; then install connector on fitting at approximate 11 o'clock position on inlet case. Install P_{t2} bleed control rear tube to front tube. Install gaskets on connectors on bleed valve and actuator and install them in their locations. Install rear end of P_{t2} bleed control rear tube to its connector on bleed valve and actuator. Torque and lockwire tube nuts.

(2) Install gasket on connector; then install connector in intermediate case at 12 o'clock position between two pair of mount flanges.

(3) Install gasket under screen assembly; then install screen assembly into housing. Install connector on screen housing. Torque connector.

(4) Using a new gasket, install screen housing on left side of diffuser case with bolts. Torque and lockwire bolts.

(5) Install P_{s3} bleed control tube to connector installed in step (2) and to screen housing installed in step (4). Torque and lockwire bolts.

(6) Install P_{s4} bleed control close tube to connectors on rear portion of actuator. Torque and lockwire tube nuts.

(7) Install P_{s4} bleed control open tube to connectors on bleed valve and actuator control. Torque and lockwire nuts.

(8) Install gaskets on inner and outer side of multiple connector; then secure connector to actuator with bolt to recommended torque.

(9) Secure P_{s4} bleed control intra-unit tube to the multiple connector installed in step (8) and to connector on front of bleed valve and actuator. Torque and lockwire.

E. Bleed System Air Tubes - Installation (JT3D-1-MC6 and MC-7, Temperature Biased System)

(1) Install gasket on screen; then install screen in the screen housing and secure with connector. Gasket shall be between screen and screen housing. Torque connector 400 to 450 pound inches.

AIR - MAINTENANCE PRACTICES

COMPRESSOR BLEED SYSTEM

(2) Using new gasket assembly, install screen housing on left side of diffuser case and secure with bolts. Torque and lockwire bolts.

(3) Place new gasket on connector which attaches diffuser-to-actuator control tube at bleed actuator and install connector.

(4) Install diffuser-to-adapter control tube between screen housing and actuator control. Torque and lockwire tube nuts.

(5) Install and secure clip as noted at disassembly.

(6) Place gasket on each connector and install three tube connectors in actuator control.

(7) Install three actuator control-to-bleed control rear tubes and connect tube nuts at actuator control. Torque tube nuts.

(8) Place seal on each connector and install three connectors in lower left hand elbows on inlet case.

(9) Install three actuator control-to-bleed control front tubes and connect tube nuts at inlet case. Torque and lockwire tube nuts.

(10) Connect three actuator control-to-bleed control front and rear tubes together with three actuator control-to-bleed control intermediate tubes.

(11) Using grommets, clip three actuator control-to-bleed control rear tubes together and to engine, locating them as noted at disassembly. Torque screws and nuts.

(12) Put new seal on each connector and install two connectors on fittings on compressor inlet case (upper left).

(13) Install pigtail shape inlet pressure sensing tube between two upper left connectors on inlet case. Torque and lockwire tube nuts.

(14) Using grommets, install multi-hole clamps along actuator control-to-bleed control front tubes. Fasten clamps with brackets to rear flange of fan discharge case (left side) and to bottom of front compressor front case and vane assembly. Torque screws and nuts.

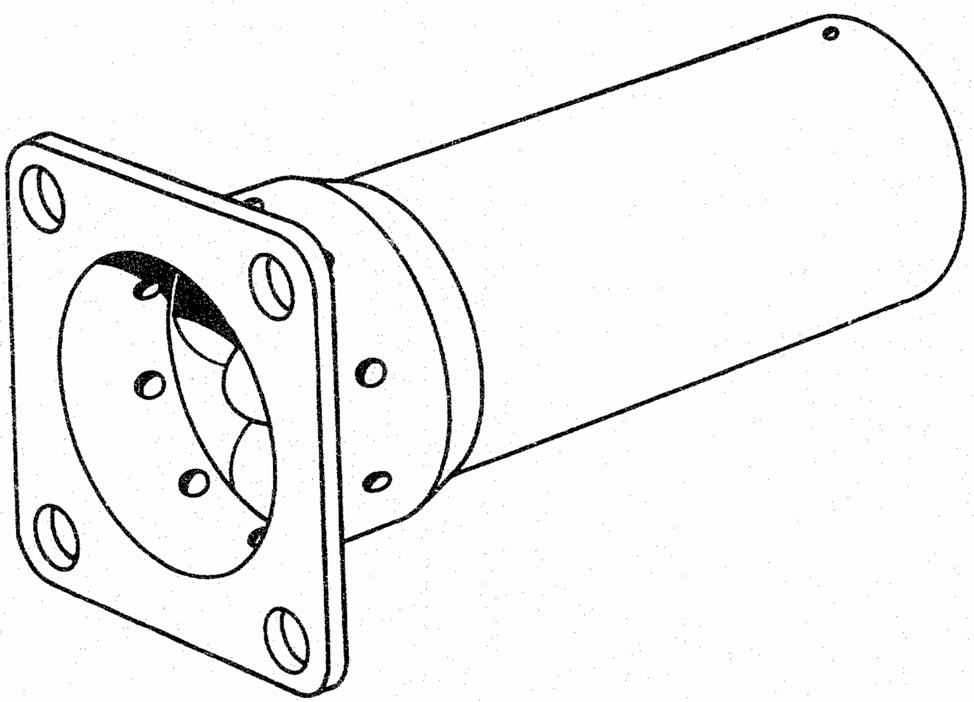
NOTE: These clamps are not secured in place until after front oil suction, tube is in position.

ANTI-ICING AIR REGULATOR - DESCRIPTION

Description

See Figure 1.

Two anti-icing air regulators, one on each side, are installed in the engine anti-icing air system. Each regulator contains a thermostatic valve which opens at low temperatures and moves towards the closed position with increasing temperature. During periods of anti-icing system operation, this valve prevents unnecessarily large quantities of hot air from being dumped into the engine inlet. Loss of engine thrust during these periods is thus kept at a minimum.



L-5257

Anti-Icing Air Regulator

Figure 1

ANTI-ICING AIR REGULATOR - MAINTENANCE PRACTICES

1. Removal/Installation of Air Regulators

Refer to Chapter 75-0, Maintenance Practices.

ANTI-ICING AIR VALVES - DESCRIPTION

Description

The right and left anti-icing air shut-off valves are identical. They are electrically operated, butterfly type. These valves are controlled from a cockpit switch, and are either fully closed or fully open.

ANTI-ICING AIR VALVE - MAINTENANCE PRACTICES

1. Removal/Installation of the Anti-Icing Air Valves

   Refer to Chapter 75-0, Engine Anti-Icing System.

   NOTE: Refer to Chapter 72-0, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of the anti-icing air valve.

BLEED CONTROL - DESCRIPTION AND OPERATION

Function

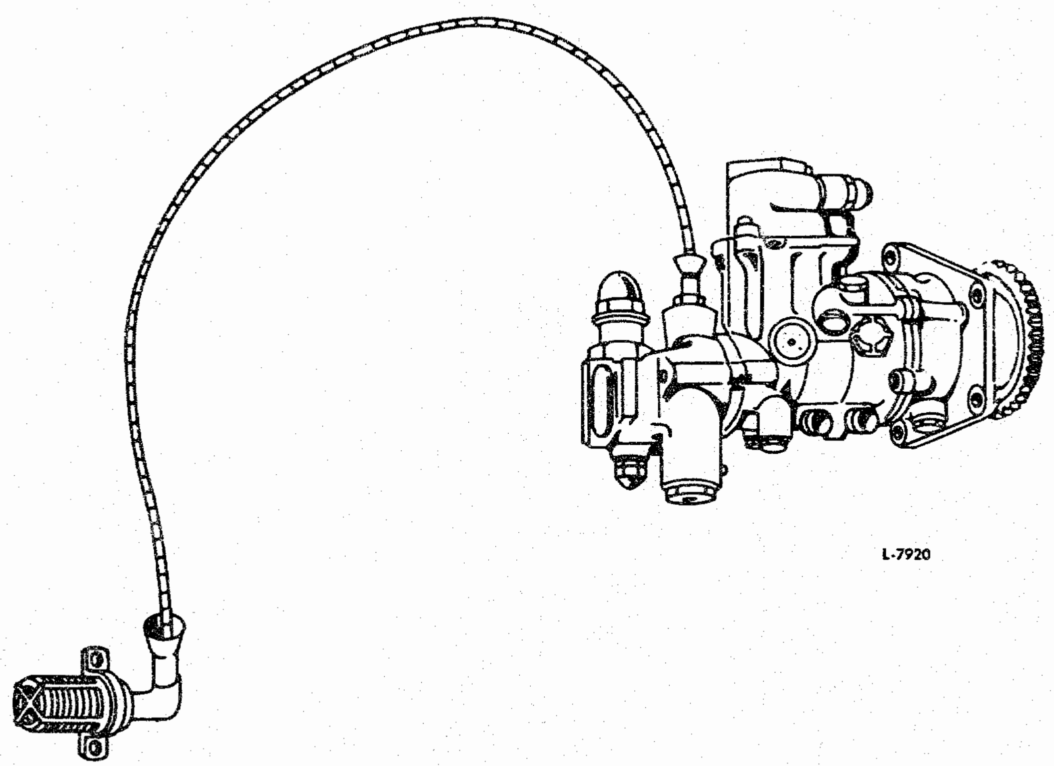
The bleed control (see Figure 1) employs air pressure (P_1) as a servo force. The function of the control is to sense low rotor speed (N_1), compressor inlet air pressure (P_{t2}) and compressor inlet air temperature (T_{t2}), and to signal the compressor bleed valves to open or close as required at a given speed, pressure, and temperature condition or combination of these conditions. The control functions through five basic systems.

Temperature Compensating System

The temperature compensating system functions to rotate the speed set cam in response to changes in compressor inlet air temperature (T_{t2}).

Altitude Compensating System

The altitude compensating system functions to establish the axial position of the speed set cam in response to a change in compressor inlet pressure.



Compressor Bleed Control

Figure 1

BLEED CONTROL - DESCRIPTION AND OPERATION

Speed Sense System

The drive gear translates low rotor speed (N_1) into outer control shaft rotation which causes the control flyweights to exert an input force (proportional to control speed) to the speed set system.

Speed Set System

The speed set system functions to establish an equilibrium between the control flyweight force (F_1) and a component of the speed set spring force, thereby allowing the bleed servo valve to assume predetermined positions.

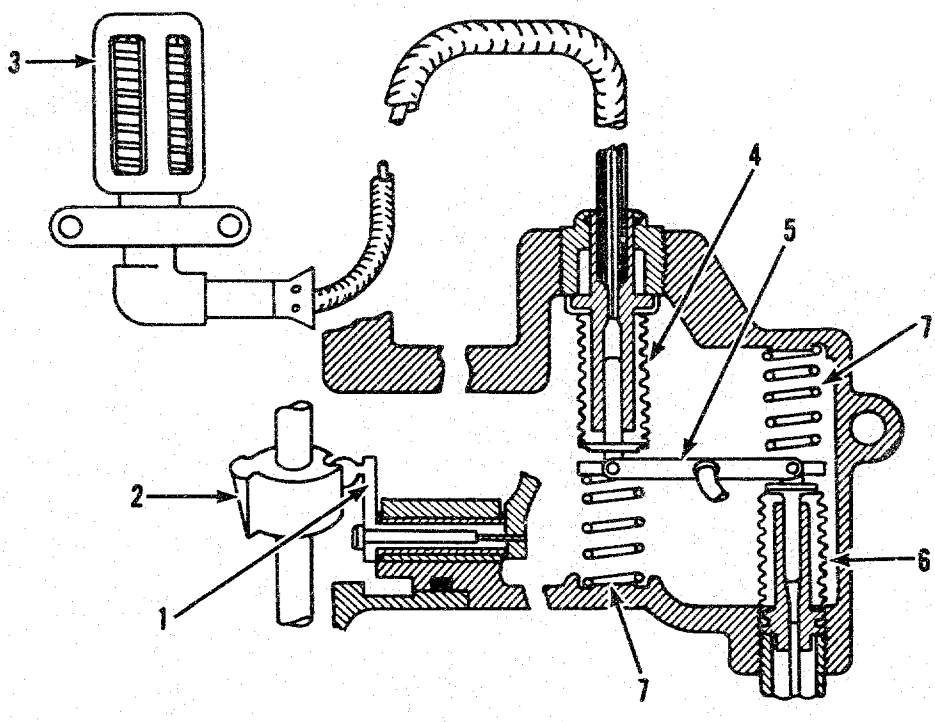
Air Pressure Regulation System

The air pressure regulation system meters compressor discharge air pressure (P_{s4}) to operating air pressure (P_1) for the purpose of operating the bleed control.

Operation

Temperature Compensating System

See Figure 2.



1. TEMPERATURE CAM LEVER
2. SPEED SET CAM
3. TEMPERATURE BULB
4. INLET AIR TEMPERATURE BELLOWS
5. TEMPERATURE CAPSULE LEVER
6. AMBIENT TEMPERATURE BELLOWS
7. TEMPERATURE CAPSULE SPRING

Temperature Compensating System

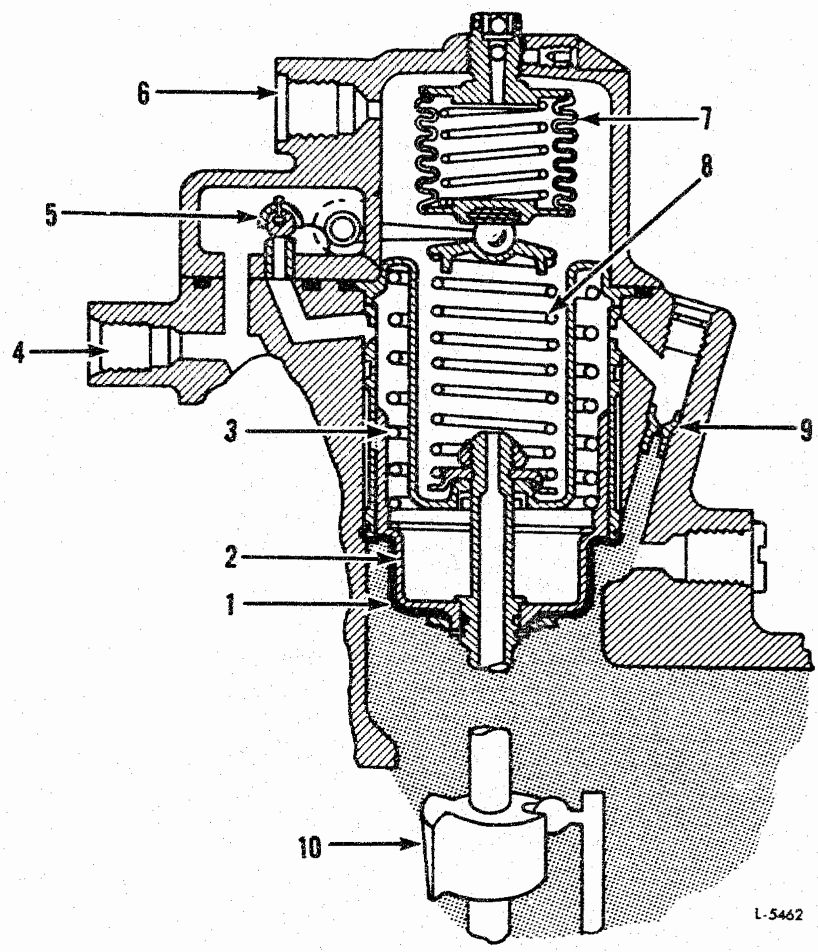
Figure 2

BLEED CONTROL - DESCRIPTION AND OPERATION

The temperature signal (T_{t2}) is introduced into the control by means of a liquid-filled thermostatic bellows. A capillary tube connects the bulb to the inlet bellows. This bellows responds to variation of compressor inlet air temperature. The other bellows compensates for variation of temperature within the control. Expansion and contraction of these two bellows moves the temperature bellows lever which is linked to the temperature cam lever. The ball end of the temperature cam lever fits into the grooved side of the speed set cam. Movement of the temperature cam lever causes radial cam movement.

Altitude Compensating System

See Figure 3.



1. ANEROID RETAINER DIAPHRAGM
2. ANEROID SLAVE PISTON
3. ANEROID SLAVE SPRING
4. P4 DISCHARGE PORT
5. ANEROID SLAVE VALVE
6. PT2 INLET (AIR)
7. ANEROID BELLOWS
8. ANEROID FEEDBACK SPRING
9. ANEROID SLAVE RESTRICTION
10. SPEED SET CAM

Altitude Compensating System

Figure 3

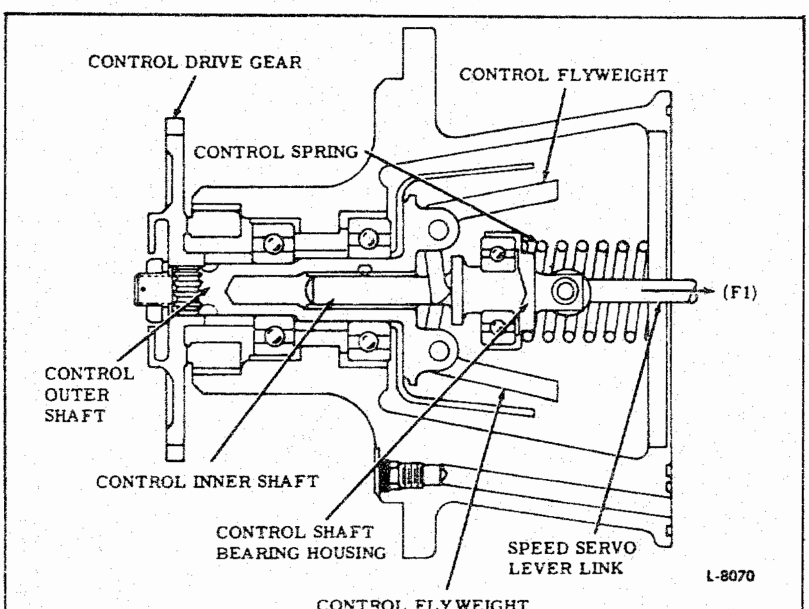
BLEED CONTROL - DESCRIPTION AND OPERATION

Compressor inlet pressure (P_{t2}) is sensed by the aneroid bellows. The bellows is linked to the aneroid servo valve. A load change on the bellows unbalances the equilibrium, the bellows net force output, and the aneroid feed back spring. A condition of unbalance allows the aneroid servo valve to change its metering position, which in turn changes the flow through the aneroid slave restriction. This change of flow changes the differential pressure across the aneroid slave piston which in turn causes the speed set cam shaft to change its axial position and the aneroid feedback spring load to return the systems to a balanced or null condition.

Speed Sense System

See Figure 4.

The bleed flange housing assembly is mounted on the aircraft engine mounting pad and is driven by the engine front accessory drive gear with a set of spur gears located on the engine. Engine speed rotates the spur gears; which in turn rotate the drive gear. The drive gear rotates the outer governor shaft. Rotation of the outer governor shaft causes the governor flyweights to open until they assume a position determined by governor spring compression. As speed increases, the flyweights exert a force against the governor inner shaft which in turn is transmitted to the bleed control shaft bearing housing. This force causes the governor spring, seated on the bleed control shaft bearing housing to compress. When the force against the governor spring becomes great enough to overcome the load preset in the spring, the bleed servo lever link moves according to the net applied governor flyweight force (F_1). Movement of the bleed servo lever link causes rotation of the bleed servo lever, which operates the bleed servo valve.



Speed Sense System

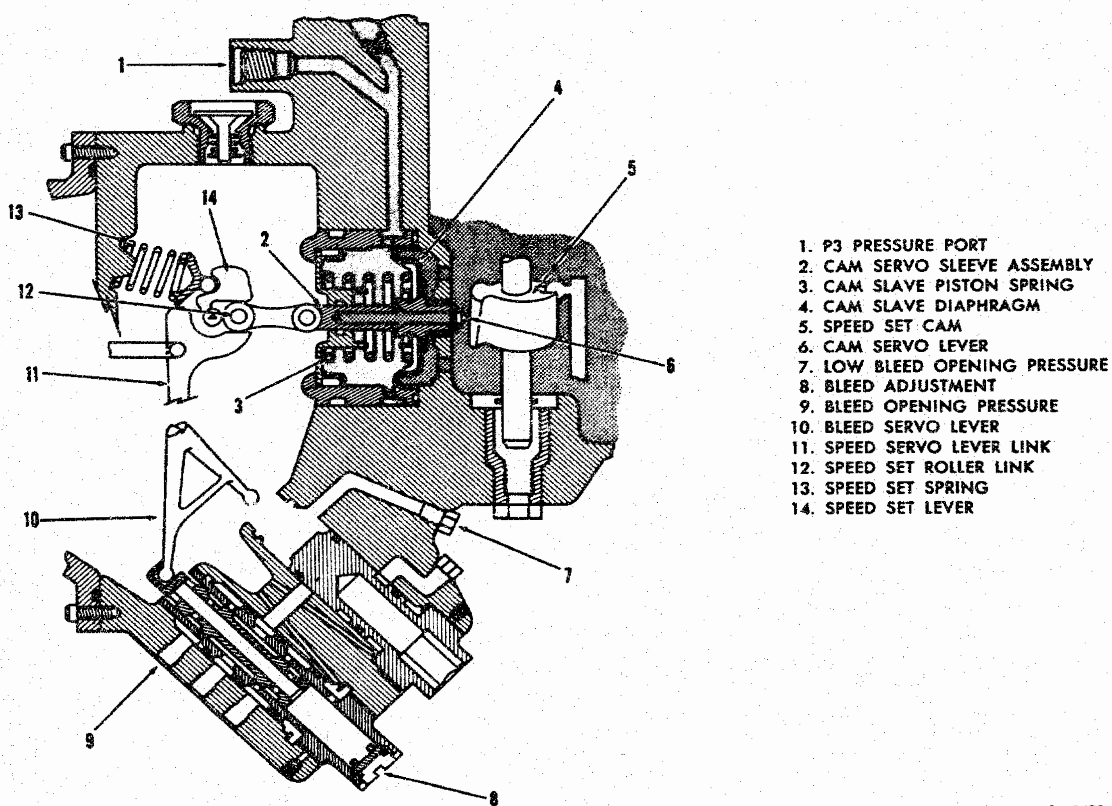
Figure 4

BLEED CONTROL - DESCRIPTION AND OPERATION

Speed Set System

See Figure 5.

The speed set cam position changes in response to the temperature compensating system and the altitude compensating system. The cam servo lever pivots on its support end. The cam servo seat, pivoted on the movable end of the lever, aligns squarely on the end of the cam servo sleeve as the cam follower (integral with the end of the lever) senses cam lift changes. Changes in position of the speed set cam cause the cam servo seat position, relative to the cam servo sleeve, to be upset, thereby changing the differential pressure across the cam servo diaphragm. The cam servo sleeve moves in response to this differential change and in turn re-establishes the equilibrium position of the sleeve relative to the seat. The cam servo sleeve is linked to the speed set roller link, so movement of the sleeve results in movement of the roller link. The speed set roller, attached to speed set roller link, functions as a movable fulcrum between the speed set lever and the bleed servo lever. A variable governor flyweight force (F_1), a measure of low rotor speed, is unbalanced by a constant speed set spring force as the rollers on the speed set roller link cause the constant speed set spring force to be applied at a variable position in such a way that the effect of this spring force increases as the roller end of the speed set roller link approaches the speed set lever pivot.



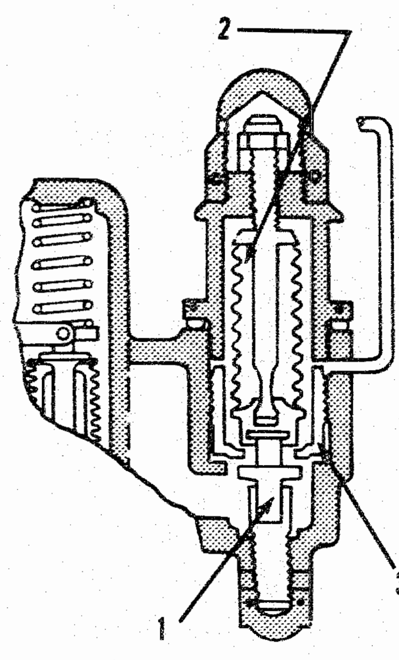
Speed Set System

Figure 5

Air Pressure Regulation System

See Figure 6.

The air pressure regulating valve bellows is vented to atmospheric pressure. Compressor discharge pressure (P_{s4}), upstream of the pressure regulating valve bellows, exerts force on neither the air pressure regulating valve bellows nor the pressure regulating valve, because of the air pressure regulating valve bellows mean effective area is matched by the area of the metering diameter of the pressure regulating valve seat. The air pressure regulating valve bellows is positioned for regulation by adjusting the regulating valve adjustment screw cap. The position of the air pressure regulating valve bellows is determined by the effect of 20 psi differential acting over the air pressure regulating valve bellows effective area compound to the force resulting from compression of the pressure regulating valve bellows. Changes in atmospheric pressure upset the 20 psi differential causing the air pressure regulating valve bellows to extend or compress. This action in turn opens and closes the pressure regulating valve. This component functions as a throttling valve, restricting the flow of (P_{s4}) air at the same time that a constant drop across the governor is maintained. Hence, any change in (P_{s4}) must represent a change in flow and will cause the pressure regulating valve to open or close accordingly.



1. PRESSURE REGULATOR VALVE
2. AIR PRESSURE REGULATOR VALVE CAPSULE
3. PRESSURE REGULATOR VALVE SEAT L-5412

Air Pressure Regulating System

Figure 6

BLEED CONTROL - DESCRIPTION AND OPERATION

Description

Temperature Compensating System

The temperature compensating system consists of the following main parts; (1) thermostatic bulb and capillary tube, (2) two thermostatic bellows, (3) two temperature bellows springs, (4) temperature bellows lever, and (5) temperature cam lever.

Altitude Compensating System

The altitude compensating system consists of the following main parts; (1) aneroid bellows lever linkage, (2) aneroid feed back spring, (3) aneroid servo valve, (4) aneroid slave piston, (5) aneroid sleeve spring, and (6) aneroid slave restriction.

Speed Sense System

The speed sense system consists of the following main parts; (1) drive gear, (2) face seal, (3) outer governor shaft, (4) ball bearing (radial), (5) compressor bleed governor inner shaft, (6) governor flyweights, (7) ball bearing (thrust), (8) bleed control shaft bearing housing, and (9) governor spring.

Speed Set System

The speed set system consists of the following main parts; (1) speed set cam, (2) cam servo lever and support assembly, (3) cam servo lever seat, (4) cam servo sleeve, (5) cam slave diaphragm, (6) cam slave spring, (7) speed set roller link, (8) speed set sleeve and roller assembly, (9) speed set lever assembly, (10) speed set spring, (11) speed servo lever link (12) bleed servo lever, and (13) bleed servo valve.

Air Pressure Regulation System

The air pressure regulating system consists of the following main parts; (1) air pressure regulating valve bellows, (2) pressure regulating valve, (3) pressure regulating valve seat, and (4) regulating valve adjustment screw cap.

BLEED CONTROL - MAINTENANCE PRACTICES

1. Removal/Installation of the Compressor Bleed Control (JT3D-1-MC6 and JT3D-1-MC7)

A. Removal

NOTE: Tag or note the location of all clips to assure their reinstallation in the same position at assembly.

(1) Unfasten and remove the compressor bleed control air tubes and oil drain tube from the control and from the front accessory support.

(2) Unfasten and remove the clips securing the control capillary tube to the front accessory support.

(3) Remove the control inlet temperature sensing bulb and bracket from the front accessory support.

(4) Remove the bulb from the spacer and the bracket.

CAUTION: DO NOT REMOVE THE CAPILLARY TUBE FROM THE CONTROL. COIL THE TUBE AND SECURE IT WITH ITS ATTACHED PARTS TO THE CONTROL WITH TAPE.

(5) Unfasten and remove the locknuts and washers securing the control to the front accessory support; then remove the control.

B. Installation

(1) Using a new gasket, install the bleed control on its five-sided mounting pad on the front accessory support with the washers and locknuts. Tighten the nuts to the recommended torque.

(2) Connect the control air tubes and oil drain tube to the control and to the front accessory support connections. Tighten the nuts to the recommended torque and lockwire.

(3) Using a new seal, install the control inlet temperature sensing bulb and bracket in its position on the outer periphery of the front accessory support with the tabwashers and bolts. Tighten the nuts and bolts to the recommended torque. Bend the tabwashers to secure.

(4) Install the clips in the locations noted at disassembly. Tighten the clip screws to the recommended torque.

FUEL DE-ICING HEATER AIR SHUTOFF VALVE - DESCRIPTION AND OPERATION

Description

The fuel de-icing heater air shutoff valve is an electrically operated butterfly valve. It is mounted on the fuel de-icing heater and is actuated by a cockpit switch. See 75-0, FUEL DE-ICING AIR SYSTEM, for a complete description of the system.

FUEL DE-ICING HEATER AIR SHUTOFF VALVE - MAINTENANCE PRACTICES

1. Removal/Installation of the Fuel De-Icing Heater Air Shutoff Valve (Optional Equipment)

   NOTE: Refer to Chapter 72-0, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of the fuel de-icing heater air shutoff valve.

   A. Removal

   (1) Remove the bolts and nuts securing the fuel de-icing air valve to the pad at the top of the fuel de-icing heater. Remove the air valve.

   B. Installation

   (1) Position the fuel de-icing air valve to the fuel de-icing heater top four-sided pad so that when mounted, the solenoid will face rearward. Secure the valve to the heater with the bolts and nuts. Tighten the nuts to the recommended torque.

TEMPERATURE BIASED COMPRESSOR BLEED VALVE AND CONTROL - MAINTENANCE PRACTICES

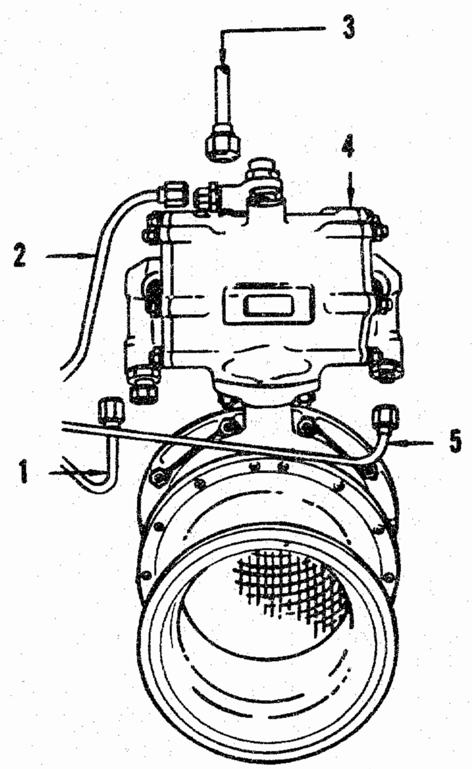
1. Removal/Installation of the Compressor Bleed Valve and Actuator Control (JT3D-1-MC6 and JT3D-1-MC7)

See Figure 201.

A. Removal

(1) Unbolt the compressor bleed valve from the compressor intermediate case.

(2) Remove the compressor bleed valve and actuator control from the engine as a complete assembly.



1. CLOSE CONTROL AIR LINE
2. BLEED CONTROL SUPPLY LINE
3. AIR SUPPLY LINE
4. ACTUATOR
5. OPEN CONTROL AIR LINE

L-5346

Compressor Bleed and Control Assembly
(JT3D-1-MC6 and JT3D-1-MC7)
Figure 201

B. Installation

(1) Place a seal on the compressor bleed valve flange and install the bleed valve and actuator control in the pad on the intermediate case.

(2) Secure the assembly on the pad with the washers and bolts. Tighten the bolts to the recommended torque and lockwire.

2. Disassembly/Assembly of the Compressor Bleed Valve and Actuator Control (JT3D-1-MC6 and JT3D-1-MC7)

A. Disassembly

(1) Remove the two locknuts and washers which secure the compressor bleed valve assembly to the actuator control assembly.

B. Assembly

(1) Insert a new seal in the groove of the bleed valve port on the actuator housing.

(2) With the actuator piston in contact with the forward cover of the actuator assembly, select the position of the splined drive shaft so that the bleed valve will be closed within one degree and guide the splines of the valve shaft into the splines of the actuator drive shaft.

NOTE: If the splines of the bleed valve shaft and the actuator drive shaft do not line up when the valve is closed, within one degree, remove the actuator drive shaft and reposition it in the arm until proper alignment with the bleed valve shaft spline is achieved.

(3) Secure the compressor bleed valve to the actuator control with two washers and nuts. Tighten the nuts to the recommended torque.

3. Temperature Bias Bleed Valve and Control Actuation Check

(a) Apply air at 8 to 10 psig to the P_{s4} supply port on the control housing.

(b) Apply air at 11 to 13 psig, through a control valve, to the "bleed close" connection on the right cover.

(c) The valve must close without perceptible delay (less than one-half second) when the control valve is actuated.

(d) Cycle the valve 10 to 15 times.

PRESSURE RATIO COMPRESSOR BLEED VALVE AND CONTROL - MAINTENANCE PRACTICES

1. Removal/Installation of the Pressure Ratio Bleed Valve and Control Assembly

A. Compressor Bleed Valve and Actuator Control Assembly - Removal (JT3D-1, JT3D-3 and JT3D-3B)

NOTE: This procedure is also applicable for MC-6 Boeing and MC-7 engines with Pressure Ratio Bleed System. See Section 75-5-1 for Temperature Biased Engines.

(1) Remove the bolts, washers, and nuts which secure the bleed valve and actuator control assembly to the intermediate case and remove the assembly from the engine.

NOTE: On JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7 the bleed valve is located in the lower left quadrant of the intermediate case while on the JT3D-1 Douglas, JT3D-3 Douglas and JT3D-3B Douglas, the bleed valve is located in the upper quadrant of the intermediate case.

(2) For JT3D-1 Douglas, JT3D-3 Douglas and JT3D-3B Douglas engines equipped with thrust reversers, remove the clamp, bolts and spacers securing the compressor bleed valve duct to the bleed valve and bracket; then remove the duct.

B. Compressor Bleed Valve and Actuator Control Assembly Installation (Except MC-6 and MC-7 Temperature Biased System)

NOTE: On JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7 engines bleed valve is located in lower left quadrant of intermediate case. Douglas bleed valve is located in upper left quadrant of the intermediate case.

(1) Place new seal on bleed valve and actuator control flange.

(2) Secure assembly to mounting pad on intermediate case with washers and bolts. Torque and lockwire bolts.

NOTE: Boltheads should be positioned up, with washers installed under boltheads.

(3) For Douglas engines equipped with thrust reversers, install compressor bleed valve duct. Secure it to bleed valve with clamp coupling and to bracket using bolts. Torque and lockwire bolts.

PRESSURE RATIO COMPRESSOR BLEED VALVE AND CONTROL - MAINTENANCE PRACTICES

2. Disassembly/Assembly of the Pressure Ratio Bleed Valve and Actuator Control Assembly (JT3D-1, JT3D-3, JT3D-3B, MC-6 and MC-7)

A. Disassembly

(1) Remove the locknuts and washers which secure the compressor bleed valve assembly to the compressor bleed actuator control assembly and separate the valve assembly from the control.

(2) Remove the spring from inside the actuator control drive shaft.

B. Assembly

(1) Coat a new seal with engine oil and insert it in the valve bore in the control housing.

(2) Insert the spring in the actuator control drive shaft.

(3) Connect an air supply hose to the close connection at the rear end of the actuator of the control and induce an air supply of 8 to 10 psig.

NOTE: This will place the actuator piston against the forward (close) end of the actuator housing. If an air supply is not available, it will be necessary to remove the rear cover of the actuator and manually move the piston to this position.

(4) With the actuator piston in contact with the forward end of the actuator, select the position on the splined drive shaft of the control so that the bleed valve will be closed within one degree, and guide the splines of the valve shaft into the splines of the actuator drive shaft.

NOTE: If the splines of the bleed valve shaft and actuator drive shaft do not line up when the valve is closed within one degree, remove the actuator drive shaft and reposition it in the actuator arm until proper alignment with the bleed valve shaft is achieved.

(5) Secure the compressor bleed valve to the control assembly with the washers and locknuts. Tighten the nuts to the recommended torque.

(6) Remove the air supply from the close connection or reinstall the rear cover, whichever was used.

WARNING: IF AIR WAS USED, PROTECT ALL PERSONNEL FROM POSSIBLE INJURY DUE TO THE RAPID AND FORCEFUL ACTION OF THE VALVE.

PRESSURE RATIO COMPRESSOR BLEED VALVE AND CONTROL - MAINTENANCE PRACTICES

3. Pressure Ratio Bleed Valve and Control Actuation Check

(a) Apply air at 10 psig to the P_{s4} supply port.

(b) Apply air at 6 psig, through a control valve, to the P_{s3} port on the rear housing.

(c) The valve must close without perceptible delay (less than one-half second) when the control valve is actuated.

(d) Cycle the valve 10 to 15 times.

LIST OF EFFECTIVE PAGES

Please insert the revised pages into this manual and delete obsoleted pages in accordance with the following List of Effective Pages. Revised pages are indicated by the letter "R", added pages by the letter "A", and deleted pages by the letter "D". Superseded pages shall be removed and destroyed.

The List of Effective Pages records not only each page of subject revision but also each previously issued page which is still current. Blank pages and pages which are no longer current do not appear on this list. If there is any question about the currency of the recipient's copy, it is recommended that each page of the manual be checked off against this List of Effective Pages. Any page which does not check out with this list, either by number or by date, shall be discarded.

TABLE OF CONTENTS

ENGINE INDICATING SYSTEMS - DESCRIPTION

1. Temperature Indicating System

The temperature indicating system consists of six thermocouple probes which are located in the turbine discharge passage and are gathered together in a harness. This system provides an average temperature reading to the cockpit and individual readings for maintenance purposes.

2. Pressure Indicating System

The pressure indicating system consists of six pressure rakes which are located in the turbine discharge passage and are connected to an averaging manifold on the turbine exhaust case. This system provides measurement of turbine discharge total pressure and is used for setting engine thrust and checking engine performance.

TEMPERATURE INDICATING SYSTEM - DESCRIPTION AND OPERATION

General

The averaging temperature measurement provided by this system is an operating limit on the engine and is used also to monitor the mechanical integrity of the turbines as well as to check engine condition during operation. Each of the six dual junction thermocouple probes contain two thermocouple junctions; one set of thermocouples is connected together to provide an average exhaust gas temperature indication on the pilot's panel, and one set of thermocouples is connected together to allow maintenance crews to check exhaust gas temperature spread by reading indications from each individual thermocouple.

TEMPERATURE INDICATING SYSTEM - MAINTENANCE PRACTICES

1. Periodic Inspection

A. General

(1) These inspection procedures are a normal function of operating organizations. They consist of required inspections and minor adjustments necessary on the engine. The nature and conditions of engine operation determine the time interval between required inspections. For this reason, the intervals described in the Periodic Inspection Chart in this section are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because the extensive mass air flow tends to draw foreign objects into the engine. Thoroughly clean the entire engine compartment with a vacuum cleaner after completion of any work. Keep the compartment free of dirt, oil and grease, and remove any small unused parts, such as nuts, washers, and pieces of lockwire. Immediately cover all apertures resulting from the disconnection of tubing or parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect the exterior of the engine without dismantling to ensure that all connections are tight and free from leaks and that lines, tubing, and controls are secure and properly locked.

B. Periodic Inspection Chart

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
Thermocouples and Harness	a. Burned, broken deformed probes.		X	X
	b. Security of wires at probes.		X	X
	c. Security of probes.		X	X
	d. Continuity and insulation resistance of harness and lead assembly.		X	X
	e. Chafed or broken wiring.		X	X
	f. Proper calibration of T_{t7} system.			X

TEMPERATURE INDICATING SYSTEM - MAINTENANCE PRACTICES

2. Exhaust Gas Temperature Spread Check

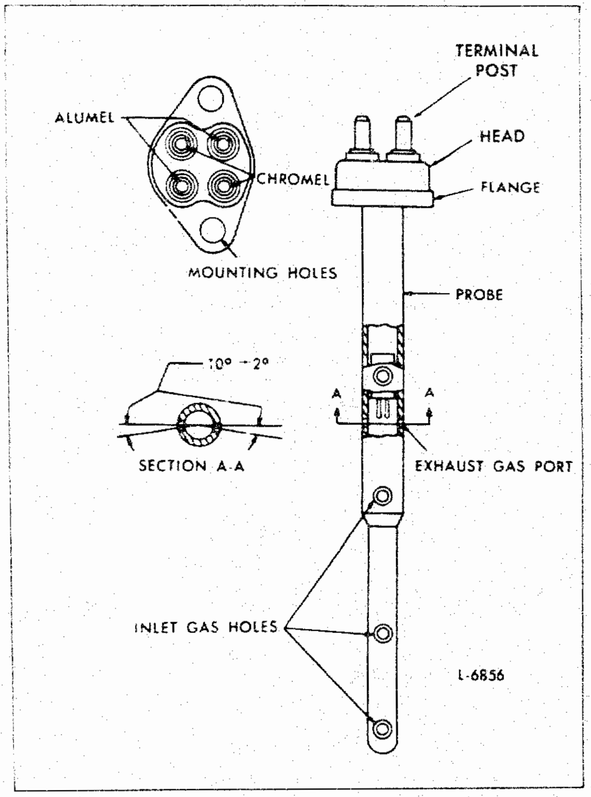
In order to periodically evaluate the physical condition and flow characteristics of the fuel nozzles, it is recommended that an exhaust gas temperature spread check be made if engine shows signs of increasing EGT or other "hot section" distress. If failure to meet the EGT spread check is due to an unusual reading in one probe, replace this probe and repeat test. Since the purpose of this test is to evaluate the flow characteristics of the fuel nozzles, refer to Chapter 72-0, Engine Adjustment/Test, for the complete procedure.

NOTE: The integrity of the testing equipment must also be checked.

THERMOCOUPLES - DESCRIPTION AND OPERATION

General

The thermocouple incorporates two junctions within a common sampling type probe. See Figure 1. One junction provides indications which are averaged with indications from other thermocouples by an averaging harness. The other junction is for individual readings. The thermocouple junctions, studs, and wiring are made of chromel and alumel material. The nuts and stud diameters of the alumel terminals are larger than those of the chromel terminals. Each thermocouple has two sets of chromel and alumel studs. One set (rearmost) is for average indications and the other is for individual indications. Each assembly incorporates four gas inlet holes and one gas discharge hole.



Thermocouple
Figure 1

THERMOCOUPLES - REMOVAL/INSTALLATION

1. Removal/Installation of the Thermocouples

A. Removal

(1) Disconnect the harness thermocouple leads at each thermocouple. Remove the bolts and locknuts which secure each of the six thermocouples to the turbine exhaust case. Remove the thermocouples and harness supporting brackets.

B. Installation

(1) In the area to the rear of the turbine exhaust case mount rings, install the six thermocouples in the raised bosses of the case. Secure each to the boss flange with the bolts and locknuts. Tighten the bolts to the recommended torque. Connect the harness thermocouple leads at each thermocouple.

NOTE: To ensure proper locking of JT3D-3B-DL thermocouple system terminal lug locknuts (Klincher locknuts) cylindrical grooved portion of nut must lead way onto terminal stud (be inboard when installed).

THERMOCOUPLES - INSPECTION/CHECK

1. Inspect the Thermocouples

A. Visual Inspection

(1) Inspect all surfaces of the thermocouple for nicks, cracks, bending or evidence of heat errosion.

(2) Check the probe for straightness. The allowable deformation is 1/8 inch for the small OD (lower end) of the probe.

(3) Minor nicks in the shield are not cause for rejection. Cracks at any location are cause for rejection.

(4) Do not attempt to repair minor bends in the shield.

(5) Check exhaust and inlet port openings for carbon build-up. If necessary, remove carbon with a straight piece of steel wire.

(6) Check the probe for looseness.

(7) Inspect the terminal for looseness or thread damage. Deformation of 0.025 inch is allowable if the posts are not loose and the thermocouple is electrically sound.

B. Continuity and Resistance Check

NOTE: Insulation resistance values slightly below the limits set forth below will not result in a defective EGT System. It does, however, clearly indicate that the insulation is deteriorating and will result in eventual shorts or deficient EGT readings. Therefore, EGT System components with resistance readings below the limits set forth require attention to restore the insulation resistance readings to acceptable values and prevent further deterioration and EGT system failure.

(1) Using sensitive ohmmeter or wheatstone's bridge, check continuity and resistance of thermocouple. Internal resistance of thermocouple must not exceed 0.250 ohm.

(2) Using low voltage ohmmeter, check insulation resistance between both chromel and alumel terminals and body or thermocouple for minimum of 25 seconds for each measurement. Resistance must be at least 10,000 ohms. If resistance is within limits, thermocouples shall be returned to service.

NOTE: Low voltage ohmmeter utilizing less than 40 volts (DC) and maintained at an accuracy of 5% shall be used for determining insulation resistance. Megger or other high voltage test shall not be used under any circumstances.

THERMOCOUPLES - INSPECTION/CHECK

C. Functional Test

(1) If continuity and resistance check indicates suspicion of trouble, perform functional test of thermocouples. Functional test consists of subjecting thermocouple to actual temperature variations and checking response voltages. A temperature - controlled oven will provide temperature elevation, and pyropotentionmeter will give thermocouple readings directly in degrees of temperature. Thermocouple response within 7°F (4°C) or laboratory standard accuracy at 923°F (500°C) is regarded as acceptable.

THERMOCOUPLE - CLEANING

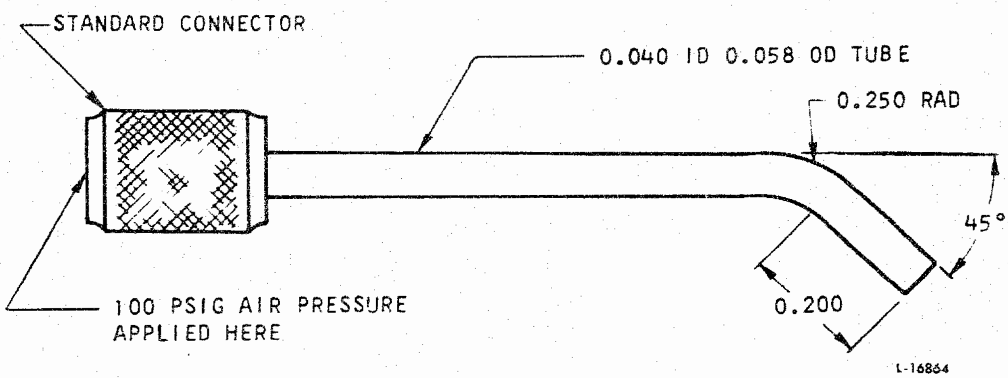
1. Grit Blasting

A. Grit blast thermocouple head with A.C. Cleaning Compound Type 2.

CAUTION: BLAST HEAD ONLY ENOUGH TO REMOVE CARBON FROM BETWEEN STUDS AND ADJOINING ANNULUS. AFTER COMPLETION OF BLASTING, USE SHOP COMPRESSED AIR TO REMOVE RESIDUE.

2. Thermocouple Internal Cleaning

A. Remove carbon around thermocouple internal leads by inserting a small nozzle into probe exhaust holes. Direct air blast at approximately 100 psig through nozzle. A nozzle may be fabricated from stainless steel tubing as shown in Figure 701.



Thermocouple Cleaning Air Nozzle
Figure 701

THERMOCOUPLE HARNESS AND LEADS - DESCRIPTION AND OPERATION

General

The thermocouple harness consists of an electrical conduit mounted on the outer circumference of the exhaust case. This harness contains six sets of branch leads which attach to the connections on the six dual junction thermocouples installed in the exhaust case. This harness is designed to provide both an average of the indications of the six thermocouples and also indications of each individual thermocouple. Attached to the harness is the thermocouple lead which is routed forward along the right side of the engine and terminates at an independent junction box on the lower quadrant of the fireseal (JT3D-1 Boeing or JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6, and JT3D-1-MC7) or forward along the left side and terminates at an independent junction box at the approximate 11:30 o'clock location on the fan discharge case front flange (JT3D-1 Douglas, JT3D-3 Douglas or JT3D-3B Douglas). The thermocouple lead is routed forward along the left side of the engine and terminates at an independent junction box at the approximate 7:00 o'clock location on the diffuser case (JT3D-3B-DL). The exhaust gas thermocouple lead is not routed through the engine junction box since it is important to keep it isolated to avoid possible adverse effects from other circuits which would result if it were tied to the common connector at the engine junction box.

THERMOCOUPLE HARNESS AND LEADS - REMOVAL/INSTALLATION

1. Engine Indicating System

NOTE: Tag or note the location of all clips and/or clamps being removed, to assure their reinstallation in the same location at assembly.

A. Thermocouple Lead Assembly - Removal (JT3D-1 Boeing, JT3D-3 Boeing and JT3D-3B Boeing)

(1) Remove the screws and nuts securing the thermocouple lead assembly to the 5:30 o'clock location of the forward flange of the turbine exhaust case, the clamp on the rear flange of the combustion chamber rear outer case, and No. 6 Bearing intermediate tube assembly.

(2) Remove the screws and locknuts securing the thermocouple lead junction to the plate on the forward face of the fireseal at the 5:30 o'clock position.

(3) Pull the rear end of the lead assembly forward through the fireseal and remove it from the engine.

CAUTION: IN ALL HANDLING OR STORAGE, THE LEAD SHOULD BE HUNG ON A RACK OR LAID ON A CLEAN TABLE FREE OF OIL AND MATERIAL WITH WHICH IT MAY BECOME ENTANGLED. SEVERE REPEATED FLEXING AND HARD BENDING OR TWISTING WILL BREAK OR FRAY THE EXPOSED INSULATION. IF HUNG ON A RACK, CARE MUST BE TAKEN NOT TO PLACE ANY SMALL RADIUS BENDS IN ANY PART OF THE ASSEMBLY.

B. Thermocouple Lead Assembly - Removal (JT3D-1 Douglas, JT3D-3 Douglas and JT3D-3B Douglas)

(1) Remove the screws and nuts securing the thermocouple lead assembly to the 5:30 o'clock location of the forward flange of the turbine exhaust case, the rear flange of the combustion rear outer case, the front flange of the combustion chamber front outer case, and the 11:30 position on the rear flange of the fan discharge case.

(2) Remove the screws and locknuts securing the thermocouple lead junction to the front flange of the fan discharge case at the approximate 11:30 position.

(3) Remove the rearmost clips; then pull the rear end of the lead assembly forward through the fireseal and remove the lead assembly from the engine.

CAUTION: IN ALL HANDLING OR STORAGE, THE LEAD SHOULD BE HUNG ON A RACK OR LAID ON A CLEAN TABLE FREE OF OIL AND MATERIAL WITH WHICH IT MAY BECOME ENTANGLED. SEVERE REPEATED FLEXING AND HARD BENDING OR TWISTING WILL BREAK OR FRAY THE EXPOSED INSULATION. IF HUNG ON A RACK, CARE MUST BE TAKEN NOT TO PLACE ANY SMALL RADIUS BENDS IN ANY PART OF THE ASSEMBLY.

THERMOCOUPLE HARNESS AND LEADS - REMOVAL/INSTALLATION

C. Thermocouple Harness - Removal

(1) Remove the two screws at the connecting lugs of the thermocouple harness lead and the thermocouple lead assembly located at the approximate 5:30 o'clock position of the turbine exhaust case.

(2) Remove the screws and locknuts securing the thermocouple harness lead junction to the bracket at the six o'clock position on the forward flange of the turbine exhaust case and remove the junction and its cover.

(3) Disconnect the harness thermocouple leads at each thermocouple.

(4) Unfasten the screws and nuts securing the thermocouple harness to the clamps on the thermocouple bosses, the exhaust case, and the No. 6 Bearing scavenge rear tube; then remove the thermocouple harness.

CAUTION: IN ALL HANDLING AND STORAGE, THE HARNESS SHOULD BE HUNG ON A RACK OR LAID ON A CLEAN TABLE FREE OF OIL AND MATERIAL WITH WHICH IT MAY BECOME ENTANGLED. SEVERE REPEATED FLEXING AND HARD BENDING OR TWISTING WILL BREAK OR FRAY THE EXPOSED INSULATION. IF HUNG ON A RACK, CARE MUST BE TAKEN NOT TO PLACE ANY SMALL RADIUS BENDS IN ANY PART OF THE ASSEMBLY. IT IS DESIRABLE TO HANG THE HARNESS ON A RACK WHICH IS SIMILAR TO A SEGMENT OF THE ROOT DIAMETER CIRCLE.

D. Thermocouple Harness and Cable Assembly Installation (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing)

(1) Position thermocouple harness to rear of turbine exhaust case with center of harness at six o'clock position of exhaust case; then secure harness to thermocouple bosses, turbine exhaust case clamp, and No. 6 Bearing rear scavenge tube with clips in positions noted at disassembly. Torque clip screws and nuts.

(2) Arrange harness branch leads to large radius bends and install them on thermocouple terminals. Torque terminal nuts.

NOTE: Nuts and stud diameters of alumel terminals are larger than those of chromel terminals. Each thermocouple has two sets of chromel and alumel studs. One set (rearmost) is for average indications and other is for individual indications.

(3) For engines incorporating harness cable assembly, P/N 421486, position front end of harness cable in bracket at approximately 5:30 o'clock location on rear flange of turbine case: secure with screws and locknuts. Torque screws.

THERMOCOUPLE HARNESS AND LEADS - REMOVAL/INSTALLATION

(a) Connect rear end of lower front thermocouple cable to front end of harness cable at rear flange of turbine case. Torque screws.

NOTE: Make certain front cable chromel lead is connected to harness cable chromel lead and front cable alumel lead to harness cable alumel lead.

(b) Install forward end of lower front thermocouple cable in larger opening in fireseal at approximately five o'clock location and secure in position with retaining plates, screws, and nuts. Torque screws and install cover on cable connector on front face of fireseal.

(c) Position rear lugs of upper front thermocouple cable to those of harness cable at approximately five o'clock location on exhaust case and fasten them together with screws. Torque screws.

NOTE: Make certain chromel lead of front cable is connected to chromel lead of harness cable and front cable alumel lead to harness cable alumel lead.

(d) Insert forward lugs of upper front thermocouple cable through opening in fireseal and secure cable to fireseal with plate, clip, screws, and nuts. Torque screws.

(e) Reinstall clips removed at disassembly to locations noted at disassembly securing them with screws and nuts. Torque screws.

(4) For engines incorporating harness cable assembly, P/N 467810, route thermocouple cable, with its two branched ends, forward to combustion chamber fireseal. Secure cable with clips at locations noted at disassembly. Torque clip screws.

(a) Position longer thermocouple branch lead to plate on forward face of fireseal at five o'clock location and secure it with screws and locknuts. Torque screws.

(b) Secure lead to turbine pressure sensing tube with clip, screw, and nut at location noted at disassembly. Torque screws.

(c) Install shorter thermocouple branch lead in hole in fireseal above previously installed thermocouple lead and secure it with screws and locknuts. Torque screws.

THERMOCOUPLE HARNESS AND LEADS - REMOVAL/INSTALLATION

G. Thermocouple Harness - Installation JT3D-3B-DL Engines)

NOTE: To ensure proper locking of JT3D-3B-DL thermocouple system terminal lug locknuts (klincher locknuts) cylindrical grooved portion of nut must lead way onto terminal stud (be inboard when installed).

(1) Position branched cables to rear OD of exhaust case. Secure with clips and screws. Torque screws.

(2) Arrange branched leads to large radius bends and install them on two forward thermocouple terminals. Torque terminal nuts to recommended torque.

NOTE: Nuts and studs of alumel terminals are larger than those of chromel terminals. Each thermocouple has two sets of chromel and alumel studs. One set (rearmost) is for average indications and other is for individual indications.

H. Thermocouple Cable Assembly - Installation (JT3D-3B-DL Engines)

NOTE: To ensure proper locking of JT3D-3B-DL thermocouple system terminal lug locknuts (Klincher locknuts) cylindrical grooved portion of nut must lead way onto terminal stud (be inboard when installed.

(1) Secure thermocouple cable front terminal box assembly to bracket attached to pad at seven o'clock position on diffuser case. Attach thermocouple loop clamp half to rearward portion of same bracket.

(2) Install chromel bus bar, P/N 557766, over short studs of terminal box installed in step (1) and alumel bus bar, P/N 557767, over longer studs. Then attach four leads of front cable assembly to appropriate terminals of terminal box and secure leads and bus bar on short studs with P/N 558433 nut and on longer studs with P/N 558434 nut.

NOTE: Alumel terminal of cable has larger hole than chromel terminal lead; therefore, alumel lead is attached to large diameter studs of terminal box.

(3) Clip thermocouple branched cable assembly to brackets on engine with clips and screws in locations noted at disassembly.

THERMOCOUPLE HARNESS AND LEADS - REMOVAL/INSTALLATION

(4) Attach two thermocouple cable rear terminal boxes, one to terminal bracket at approximate 11 o'clock position. Install plain bolt through terminal box at the 5:30 o'clock position. Install plain bolt through terminal box forward hole and into nut on back side of terminal bracket and other 12 point head bolt into rear hole of terminal box and through bracket hole. Install nut. Torque forward bolt and rearward nut to specified torque. Lockwire forward bolt. The preceding applies to both upper and lower terminal boxes.

(5) Install bus bar, P/N 558431, to short studs of terminal box at top of exhaust case and bus bar, P/N 558432, to longer studs of terminal box. Then connect cable leads to appropriate studs of terminal box and secure with nuts. Nut, P/N 558434 located on short studs and nut, P/N 558433, located on longer studs.

NOTE: Make certain cable chromel terminal (small hole) is connected to chromel bus bar and alumel terminal (larger hole) is connected to alumel bus bar. Chromel cable terminal is connected to small studs and alumel cable terminal is connected to larger stud.

(6) Connect lower branch of front cable to terminal box at bottom of exhaust case in same manner as for upper branched cable in step (5).

THERMOCOUPLE CABLE AND LEADS - INSPECTION/CHECK

1. Electrical Tests

See Figures 601, 602, 603, and 604.

A. General

The validity of electrical tests made in the field may depend upon limitations inherent in the common ohmmeter. This instrument is not dependable for determining the exact wire resistances of the thermocouple cable. It may, however, be used to detect gross failures such as open or intermittent circuits, and metal-to-metal short circuits. Also, approximate insulation resistance may be checked if certain precautions are observed. The ohmmeter used in the following tests must be of good quality and in good condition; i.e. free from "stickiness" of the meter needle, with pinjacks firm, test leads sound, and dry cells in condition to permit full scale deflection for all positions of the range switch.

B. Averaging System Check

To check the averaging circuit, place a soldering iron of at least 500 watts capacity in contact with one of the thermocouples. Observe the cockpit instrument for a deflection of the needle thereby proving continuity. Allow a sufficient period of time to elapse for the instrument needle to show a decrease in reading; then repeat the procedure with successive thermocouples until all of them have been checked.

NOTE: This is not intended as a calibration check of the thermocouple.

C. Thermocouple Cable Continuity Check

See Figures 601 and 603.

(1) If the results of Paragraph B indicate a discontinuity in either the averaging or the individual reading system, disconnect the thermocouple lead at the mount bracket; then proceed as follows:

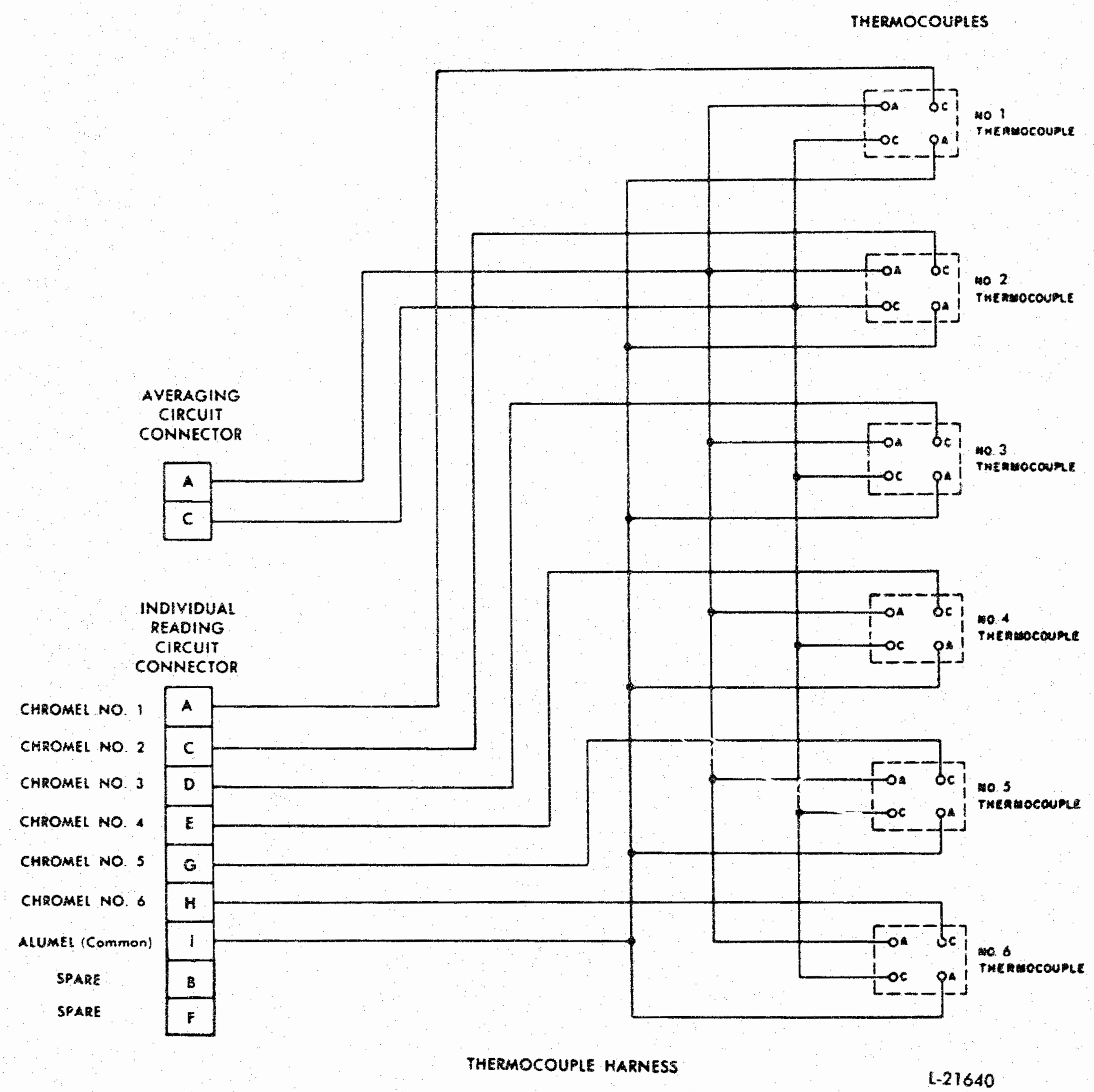
(a) Set ohmmeter range switch to a range which has center scale value of approximately ten ohms.

NOTE: Broken wires which come into contact intermittently due to flexing will cause needle to fluctuate. False intermittent indications will result if ohmmeter prods are not in firm contact with clean terminals; also, if ohmmeter prods, leads, or jacks are defective.

(b) Perform continuity check in accordance with referenced schematic.

(c) Reject any assembly for discontinuity.

THERMOCOUPLE CABLE AND LEADS - INSPECTION/CHECK



Thermocouple Cable Wiring Diagram (P/N's 434505, 467810 and 558285)
Figure 601

THERMOCOUPLE CABLE AND LEADS - INSPECTION/CHECK

D. Thermocouple Cable Insulation Resistance Check

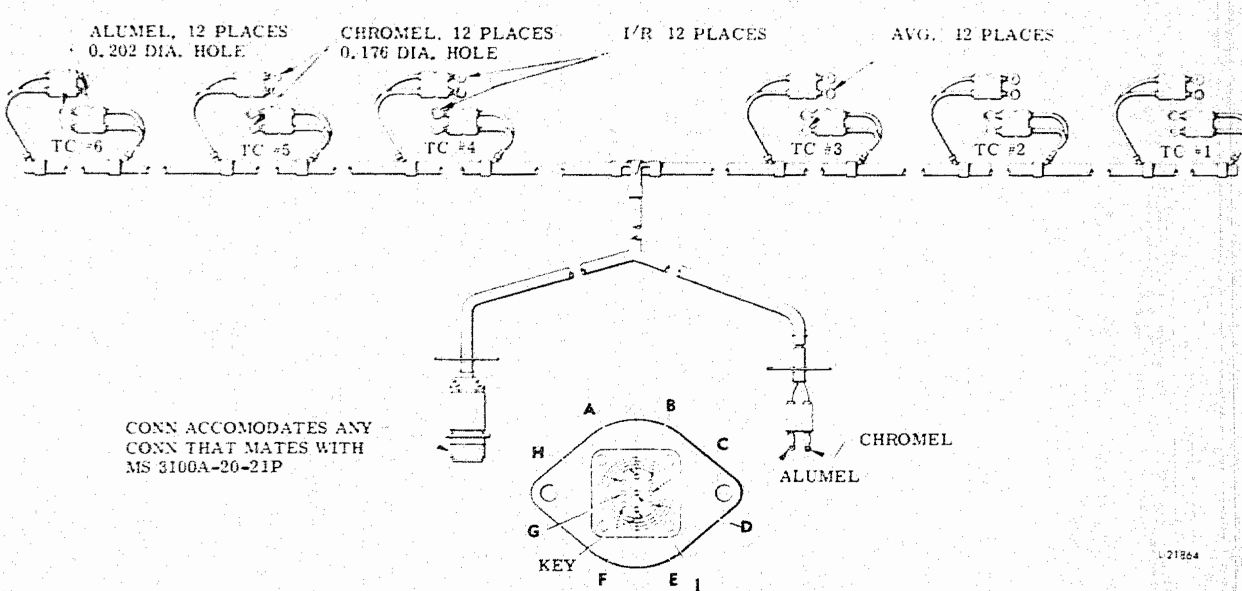
NOTE: Insulation resistance values slightly below the limits set forth below will not result in a defective EGT system. It does, however, clearly indicate that the insulation is deteriorating and will result in eventual shorts or deficient EGT readings. Therefore, EGT system components with insulation readings below the limits set forth require attention to restore the insulation resistance readings to acceptable values and prevent further deterioration and EGT system failure.

(1) Ensure that the thermocouple cable and leads are properly installed and connected.

(2) Using low voltage ohmmeter, check insulation for short circuits, excessive leakage, and internal insulation chafing discrepancies. Check proper operation of instrument by touching test prods together and noting needle deflection to read zero ohms.

NOTE: Low voltage ohmmeter utilizing less than 40 volts (d.c.) and maintained at an accuracy of five percent shall be used for determining insulation resistance. Megger or other high voltage test shall not be used under any circumstances.

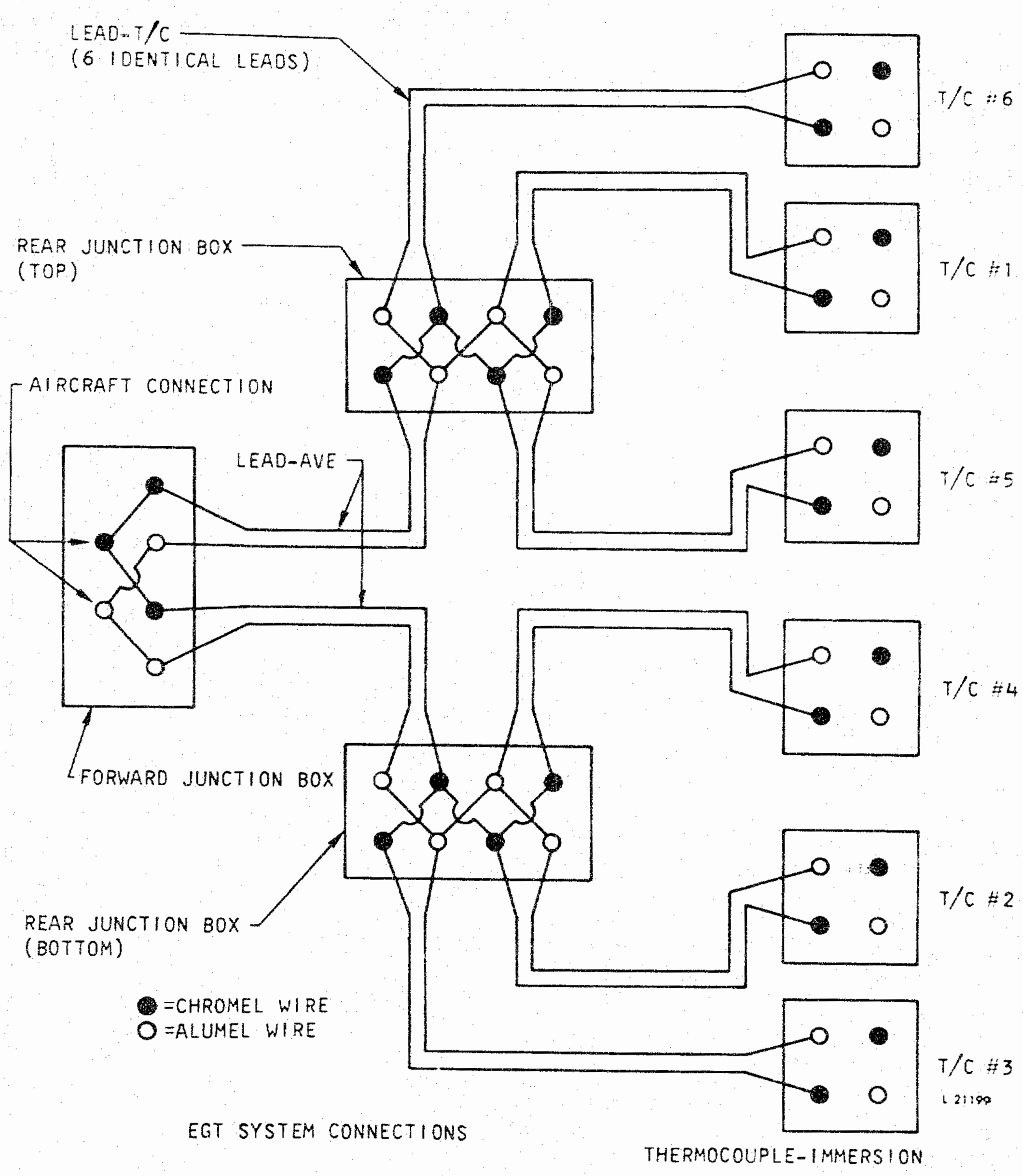
(3) Place one prod in contact with cable steel wire braid covering, and other prod in contact with alumel conductor.



Thermocouple Cable Assembly (P/N 467810)

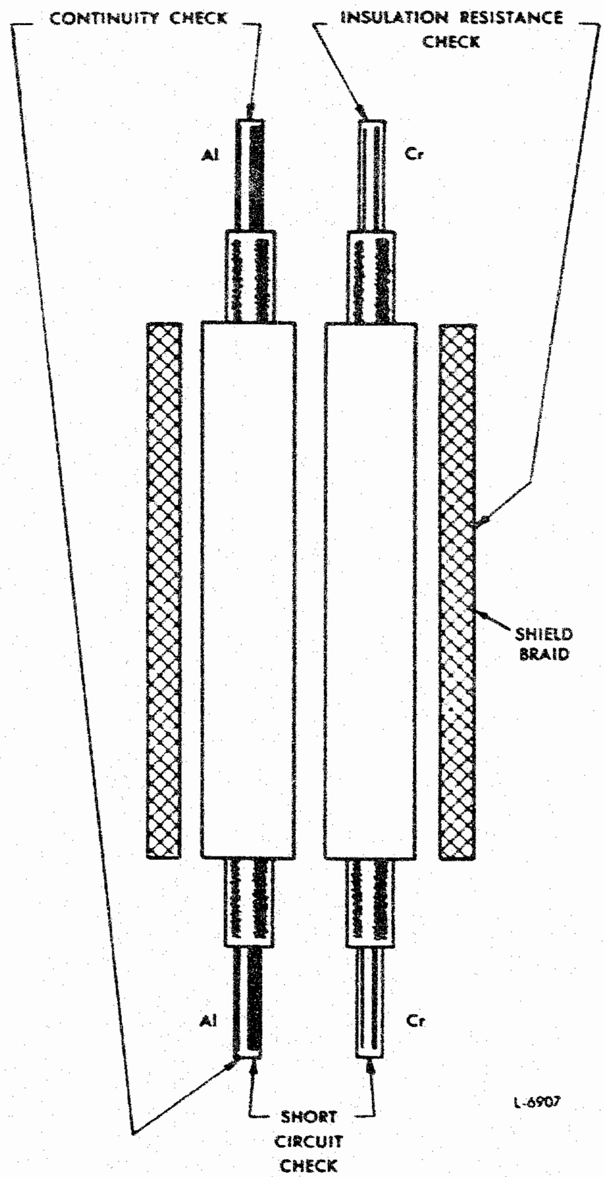
Figure 602

THERMOCOUPLE CABLE AND LEADS - INSPECTION/CHECK



Thermocouple Cable and Terminal Box Assembly Wiring Diagram
(P/N's 558407, 558430, 558435, and 558438)
Figure 603

THERMOCOUPLE CABLE AND LEADS - INSPECTION/CHECK



Thermocouple Cable Test
Figure 604

THERMOCOUPLE CABLE AND LEADS - INSPECTION/CHECK

(4) Read Ohmmeter. If resistance recorded is below 10,000 ohms, proceed as follows: If full-scale deflection (zero ohms) is recorded, and no terminals are in accidental contact, reject part. If large (but not full-scale) deflection is recorded, presence of carbon or excessive moisture may be indicated. Carbon yields fairly steady reading. Moisture tends to produce readings which waver or drift after 5 to 30 seconds. If presence of moisture is indicated, bake cable at 200 to 250°F (93 to 121°C) for one hour and recheck.

NOTE: False drift may be due to variations in applied voltage. To check for false drift, place prods in contact with each other for ten seconds. Readings must not wander from full-scale deflection.

(5) Repeat steps (2), (3), and (4) with one prod in contact with cable steel wire braid covering and other in contact with chromel conductor.

(6) Perform resistance check of insulation between conductors, using low voltage ohmmeter. Place one prod on chromel terminal and other on alumel terminal. If resistance recorded is below 10,000 ohms, reject part.

(7) Repeat steps (2), (3), (4), (5), and (6) above for each thermocouple cable.

E. Short Circuit Check

(1) Set ohmmeter range switch to a range which has center scale value of approximately ten ohms.

(2) Place one prod in good contact with well-cleaned alumel terminal and other in good contact with well-cleaned chromel terminal. Flex cable gently and observe instrument needle. If any deflection results (unless caused by accidental contact between other terminals of cable), reject part.

(3) Repeat steps (1) and (2) for thermocouple front cable if applicable.

F. Defective or rejected thermocouple cables fall into following basic categories.

(1) Electrical Test Rejects

(a) No continuity in circuit.

(b) Short circuit.

(c) Low insulation resistance.

THERMOCOUPLE CABLE AND LEADS - CLEANING

1. Thermocouple Cable Assembly

A. Terminals-Cleaning

CAUTION: DO NOT USE ABRASIVE GRIT OR GRIT CLOTH TO CLEAN CABLE TERMINALS. GRIT MATERIAL IMBEDDED IN TERMINAL LUGS MAY ADVERSELY AFFECT ACCURACY OF LOW LEVEL MILLIVOLT EGT SIGNALS.

(1) Clean alumel and chromel EGT terminals, as required, using stainless steel brush or stainless steel wool pad (without soap). Use shop compressed air to remove residue.

TURBINE DISCHARGE PRESSURE INDICATING SYSTEM - DESCRIPTION AND OPERATION

General

The average pressure rake manifold consists of a split tube which is mounted around the periphery of the exhaust case and which contains six integral mounting flanges. These flanges are attached to six rakes installed in the exhaust case. This manifold averages the pressure provided to it by the rakes. Airframe lines connect to the manifold and transmit the pressure for interpretation in the cockpit.

TURBINE DISCHARGE PRESSURE INDICATING SYSTEM - MAINTENANCE PRACTICES

1. Periodic Inspection

A. General

(1) These inspection procedures are a normal function of operating organizations. They consist of required inspections and minor adjustments necessary on the engine. The nature and conditions of engine operation determine the time interval between required inspections. For this reason, the intervals described in the Periodic Inspection Chart in this section are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because the extensive mass air flow tends to draw foreign objects into the engine. Thoroughly clean the entire engine compartment with a vacuum cleaner after completion of any work. Keep the compartment free of dirt, oil and grease, and remove any small unused parts, such as nuts, washers, and pieces of lockwire. Immediately cover all apertures resulting from the disconnection of tubing or parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect the exterior of the engine without dismantling to ensure that all connections are tight and free from leaks and that lines, tubing, and controls are secure and properly locked.

B. Periodic Inspection Chart

Component	Nature of Inspection	Inspection Time		
		Routine	Minor	Major
Average Pressure Indicating System	a. Burned or broken rake.		X	X
	b. Security of rake and attached line.		X	X

TURBINE DISCHARGE PRESSURE INDICATING SYSTEM - INSPECTION/CHECK

1. Leak Check

A. Whenever the exhaust gas pressure measuring system has been disturbed, the system must be checked for leakage as follows:

(1) Connect a source of clean, dry air to the exhaust gas pressure manifold.

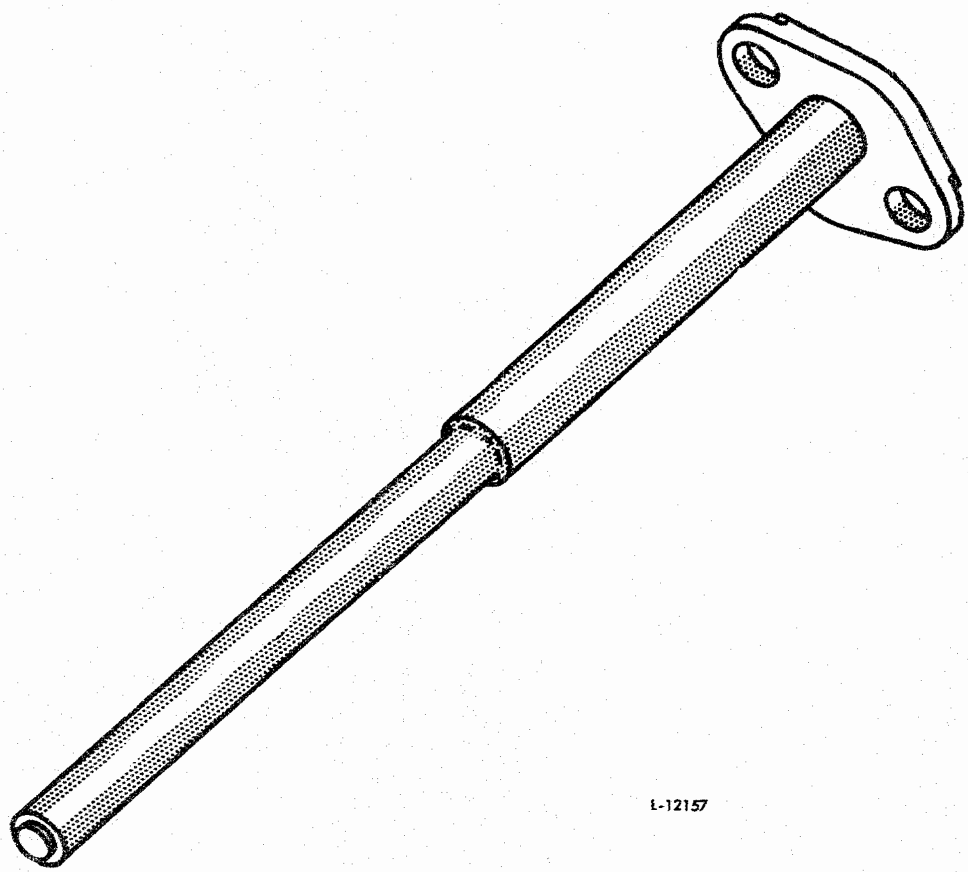
(2) Regulate the air pressure at the manifold to 100 psi gage pressure.

(3) Check each connection on the manifold and at the rakes, with a soap and water solution, for defective joints.

PRESSURE RAKES - DESCRIPTION

General

The engine has six equally-spaced drilled rakes inserted into the exhaust case forward of the exhaust case mounting flange. These rakes sample the turbine exhaust pressure which is averaged out in the pressure rake manifold.



Average Pressure Rake

Figure 1

PRESSURE RAKES - REMOVAL/INSTALLATION

1. Procedures

A. Removal

(1) Loosen the locknuts; then remove the bolts in each average pressure rake flange and remove the rakes.

B. Installation

(1) Install the average pressure rakes in their holes in the periphery of the turbine exhaust case.

(2) Secure the rakes in place with the bolts and locknuts. Tighten the bolts to the recommended torque.

PRESSURE RAKE MANIFOLD - REMOVAL/INSTALLATION

1. Procedure

NOTE: Tag or note the location of all clips to assure their reinstallation in the same location at assembly.

A. Removal

(1) Remove the screws and locknuts securing the average pressure rake manifold clips to the clamps on the forward flange of the turbine exhaust case.

(2) Unfasten the nuts at the approximate 12 and 6 o'clock positions which secure the right average pressure rake manifold to the left average pressure rake manifold.

(3) Remove the screws and the locknuts securing the flanges of the manifold to the average pressure rake boss flanges; then remove the manifolds.

B. Installation

(1) In the area forward of the turbine exhaust case mount rings, position the right and left average pressure rake manifolds so that they meet at the approximate 12 and 6 o'clock positions and so that the manifold flanges mate with the average pressure rake boss flanges; then secure the manifolds to each other with the nuts.

(2) Secure the manifold flanges to the rake boss flanges with the screws and locknuts. Tighten the screws to the recommended torque; then tighten the tube nuts to the recommended torque and lockwire.

(3) Position the clips to the clamps on the forward flange of the turbine exhaust case. Secure the clip with the screws and locknuts. Tighten the screws to the recommended torque.

LIST OF EFFECTIVE PAGES

Please insert the revised pages into this manual and delete obsoleted pages in accordance with the following List of Effective Pages. Revised pages are indicated by the letter "R", added pages by the letter "A", and deleted pages by the letter "D". Superseded pages shall be removed and destroyed.

The List of Effective Pages records not only each page of subject revision but also each previously issued page which is still current. Blank pages and pages which are no longer current do not appear on this list. If there is any question about the currency of the recipient's copy, it is recommended that each page of the manual be checked off against this List of Effective Pages. Any page which does not check out with this list, either by number or by date, shall be discarded.

TABLE OF CONTENTS

OIL SYSTEM - DESCRIPTION AND OPERATION

General

The engine oil system is a self-contained, high pressure design consisting of a pressure system which supplies oil to the main engine bearings and to the accessory drives, and a scavenge system which scavenges the bearing compartments and accessory drives. The oil is cooled by passing through a fuel-oil cooler. A breather system, interconnecting the individual bearing compartments and the oil tank, completes the engine oil system.

OIL SYSTEM - MAINTENANCE PRACTICES

1. Oil System - Limit And Maintenance

A. General

(1) Due to inherent differences in individual engines and/or engine aircraft installations, it has not been found feasible to establish specific drainage limits for the JT3D overboard breather. Each case should be evaluated on the basis of experience and engine history. An engine should be rejected for further investigation only when the following conditions exits:

(a) Discharge from the overboard breather is substantially greater than that of other engines of the same model or where a definite increase in the amount of discharge is noted for an individual engine.

(b) Oil consumption rises rapidly such that it reaches a rate one pint per hour above a previously known consumption rate or oil consumption exceeds 4 pints per hour (0.5 gal/hr).

(c) There have been reported instances of No. 1 bearing compartment static oil seepage due to residual oil not being scavenged from the bearing (No. 1) compartment prior to shutdown. One way to ensure that excessive residual oil is not being left in the bearing compartment is to run the engines up to 75 percent N2 speed prior to shutdown if oil seepage is felt to be objectionable. However this run-up may not always be convenient to perform. In this instance the following limits may be applied.

1 10 cc's of oil seepage per hour from the No. 1 bearing compartment is allowable if it is inconvenient to run engine up to 75 percent N2 speed prior to shutdown.

2 The 10 cc limit may not be measurable and should diminish over a relatively short period of time after shutdown. The seepage would be considered acceptable if it only wets the surfaces and does not accumulate into a puddle.

(2) If, during operation, engine oil temperature exceeds maximum steady state temperature limit of 270°F (132°C) for more than 15 minutes, see Oil Temperature Over Limit chart in this section.

NOTE: If oil temperature should exceed 290°F (143°C) for more than 15 minutes but does not "peg-out" to 302°F (150°C) a "fly-back" period of ten hours is permissible. "Fly-back" limit is valid only on compliance with normal corrective action (oil drained, external oil screens inspected, and cause of overtemperature corrected). Ground action as attached below will still be required following return of engine to nearest maintenance base.

OIL SYSTEM - MAINTENANCE PRACTICES

B. Oil Temperature Over Limit

(1) Corrective Action

Main Oil Temperature More Than	But Not Exceeding	Time Interval	Malfunction	Ground Action
270°F (132°C)	290°F (143°C)	More Than 15 Min.	P&WA Thermostat Other	(a) (a)
290°F (143°C)	302°F Gage (150°C) Pegged	Less Than 15 Min.	P&WA Thermostat Other	(b) (c)
290°F (143°C)	302°F Gage (150°C) Pegged	More Than 15 Min.	P&WA Thermostat Other	(c) (c)
290°F (143°C)	320°F (160°C) or the 302°F (150°C)* Gage Does Not Peg-Out	Less Than 15 Min.	P&WA Thermostat Other	(a) (a)
290°F (143°C)	320°F (160°C)	More Than 15 Min.	P&WA Thermostat Other	(c) (c)

*150°C Reading is acceptable providing needle is not pegged.

(2) Ground Action

(a) Correct cause and continue, providing no engine damage is indicated.

(b) Check thermostat and bypass valve (See Note).

1 If one is bad, the engine oil shall be drained, all external oil elements shall be inspected for foreign matter and corrective action taken for cause of overtemperature. Engine may continue in service providing no engine damage is indicated. For those engines incorporating a bypass valve only, per SB 3571, and this unit is failed, then ground action (b) applies.

2 If both elements of thermostat valve are defective - ground action (c) applies.

OIL SYSTEM - MAINTENANCE PRACTICES

(c) Comply with (b)1 oil drain and screen inspection. Additionally the gearbox accessory drive bearings will be checked for heat discoloration. If heat discoloration exists, all main bearings and seals must be removed for overhaul inspection. If no discoloration exists, a hardness check must be performed. If any bearing is found to have a hardness below the minimum limit, all main bearings must be removed for overhaul inspection. If neither heat discoloration or below Rockwell harness is found, all main bearings and seals may be considered serviceable.

NOTE: It is permissible to check the thermostat flow valve assembly as follows.

1 Ascertain that pressure relief spring housing is snug against retaining ring in the cap. Then check spring by exerting approximately 65 psig on cone which should permit bottoming.

2 The thermostatic section of the valve may be checked by dipping in 185°F (85°C) oil. The valve should lengthen at lease 0.285 inch between ambient temperature 100°F (37.38°C) and below and 185°F (85°C).

1A. Removal/Installation of the Oil Tank Oil Tubes

NOTE: The oil tank for the JT3D-1 and JT3D-3 (Douglas) is airframe supplied.

A. Removal

(1) Remove bolts securing oil tank breather elbow to intermediate case mount ring area in upper right quadrant. Remove elbow; then remove oil tank breather tube.

(2) Remove bolts and nuts securing two hole flange of oil-cooler-to-oil tank tube to mating flange on oil tank and remove nuts securing three hole flange on fuel-oil cooler; then remove oil cooler-to-oil tank tube.

(3) Loosen nuts securing gearbox-to-cooler oil tube to elbows on fuel-oil cooler and gearbox. Remove gearbox-to-cooler tube and nuts.

(4) Remove bolts and nuts securing oil tank-to-gearbox oil tube to flanged boss on lower section of oil tank and nuts securing this tube to studded boss on right side of gearbox assembly. Remove oil tank-to-gearbox oil tube.

B. Installation

(1) Install two packings on oil tank end of oil tank-to-gearbox tube and one packing on gearbox end; then position tube on studs at gearbox end and insert other end in flanged boss on lower section of oil tank. Secure tube to oil tank with bolts and nuts and to gearbox with nuts. Tighten bolts and nuts to recommended torque.

OIL SYSTEM - MAINTENANCE PRACTICES

(2) Install nuts on gearbox-to-cool tube so that threaded ends face outward; then install ferrule on plain end of tube. Install new packing and retainer on each end. Position plain end of tube to elbow on fuel-oil cooler and secure threads of nut; then secure threads of other nut to elbow on gearbox. Tighten nuts to recommended torque. Lockwire nuts.

(3) Install two packings on oil tank end of oil cooler-to-oil tank tube and one packing on cooler end; then position tube on studs at cooler and insert other end in flanged boss on left side of oil tank. Secure tube to oil tank with bolts and nuts and to cooler with nuts. Tighten bolts and nuts to recommended torque.

(4) Install two packings each on both ends of oil tank breather tube; then insert tube in opening at upper right of oil tank. Position elbow on other end of tube and using new packing, secure elbow to opening in intermediate case mount ring area in upper right quadrant with bolts. Tighten bolts to recommended torque and lockwire.

2. Removal/Installation of the Breather Tubes

NOTE: Tag or note location of clips to assure their installation in same location at assembly.

A. Breather Tubes and Connections - Removal (JT3D-1, JT3D-3, JT3D-3B, and JT3D-1-MC7)

(1) Remove clip securing rear breather tube to clamp on diffuser case front flange (JT3D-1 Boeing and JT3D-3 Boeing, JT3D-3B Boeing and JT3D-1-MC7); then remove nuts securing tube to elbow at approximate 12 o'clock position on diffuser case and the tee in the upper left quadrant of the intermediate case (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing and JT3D-1-MC7) or the upper right quadrant of the intermediate case (JT3D-1 Douglas, JT3D-3 Douglas and JT3D-3B Douglas). Remove the tube.

(2) Remove clip securing front breather tube to 1 o'clock position on fan discharge case rear flange (JT3D-1 Douglas only); then remove bolts securing front breather tube to connection on approximate 12 o'clock position on inlet case and remove nut securing tube to tee on intermediate case. Remove tube.

(3) Remove bolts securing elbow to diffuser case. Remove elbow.

(4) Remove bolts securing tee to intermediate case. Remove tee.

B. Breather Tubes and Connections - Removal (JT3D-1-MC6)

(1) Engines incorporating gearbox breather tubes.

(a) Remove the bolts securing the breather manifold to the diffuser case pad at the approximate 12 o'clock position. Remove the nut securing the breather manifold to the tee on the intermediate case upper left quadrant. Disconnect the gearbox breather tube from the breather manifold. Remove the breather manifold.

(b) Disconnect the gearbox breather tube from the accessory and components drive gearbox left accessory pad cover. Remove the clip from the diffuser case left anti-icing pad. Remove the gearbox breather tube. Remove the connector from the pad cover.

(c) Remove the bolts securing the front breather tube to the connection on the approximate 12 o'clock position on the inlet case and remove the nut securing the tube to the tee on the intermediate case. Remove the tube.

(d) Remove the bolts securing the tee to the intermediate case, and remove the tee.

(2) Engines not incorporating gearbox breather tubes.

(a) Remove the clip securing the rear breather tube to the clamp on the diffuser case front flange; then remove the nuts securing the tube to the elbow at the approximate 12 o'clock position on the diffuser case and the tee in the upper left quadrant of the intermediate case. Remove the tube.

(b) Remove the bolts securing the front breather tube to the connection on the approximate 12 o'clock position on the inlet case and remove the nut securing the tube to the tee on the intermediate case. Remove the tube.

(c) Remove the bolts securing the elbow to the diffuser case. Remove the elbow.

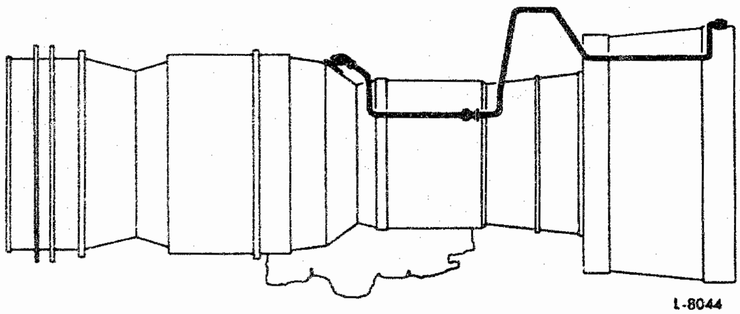
(d) Remove the bolts securing the tee to the intermediate case. Remove the tee.

C. Breather Tubes and Connections - Installation (JT3D-1, JT3D-3, JT3D-3B, and JT3D-1-MC7)

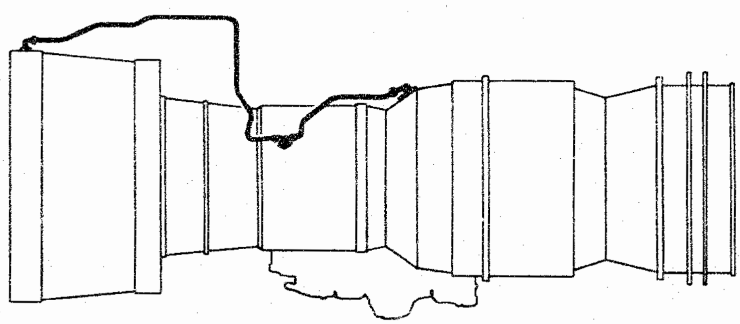
<u>NOTE</u>: See Paragraph E, for JT3D-3B-DL Engines. See Figure 201 for Douglas engines and Figure 202 for Boeing engines.

(1) Using a new packing, install breather tee on its pad in upper left quadrant of intermediate case (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, and JT3D-1-MC7) or upper right quadrant of intermediate case (JT3D-1 Douglas, JT3D-3 Douglas , JT3D-3B Douglas). Secure tee with bolts and washers. Torque and lockwire bolts.

OIL SYSTEM - MAINTENANCE PRACTICES



Breather System Tubing (JT3D-1 Douglas, D-3 Douglas and D-3B Douglas)
Figure 201



Breather System (JT3D-1 Boeing, D-3 Boeing, D-3B Boeing, and MC-6)
Figure 202

(2) Using new gasket, install breather elbow on its pad at approximate 12 o'clock position on diffuser case. Secure elbow with bolts. Torque and lockwire bolts.

NOTE: On JT3D-1 Boeing, JT3D-3 Boeing, and JT3D-3B Boeing engines install clip bracket on left and top locations of elbow flange with longer bolts. On JT3D-1-MC7, install clip bracket on two lower locations of elbow flange with longer bolts.

(3) Position flange of front breather tube to flange of connector at 12 o'clock position on inlet case and insert rear end of tube into tee on intermediate case. Secure tube to tee with tube nut and to connector with bolts and locknuts. Secure clip to bracket at one o'clock position on fan discharge case rear flange (JT3D-1 Douglas and JT3D-3 Douglas). Torque flange nuts and tube nut. Lockwire tube nut.

NOTE: On JT3D-1 Douglas, JT3D-3 Douglas and JT3D-3B Douglas, torque front breather tube nut to a torque of 110 to 120 pound-inches.

(4) On JT3D-1 Boeing, JT3D-3 Boeing, and JT3D-3B Boeing and JT3D-1-MC7 engines, install tube nuts on plain end of rear breather tube so that threads of nuts are positioned outward; then install ferrule, packing and retainer on plain end of tube and packing and retainer on ferruled end. Position tube to tee on intermediate case and elbow on diffuser case and secure it with tube nuts. Secure tube with clip to bracket on diffuser case front flange. Tighten tube rear nut on elbow to recommended torque. Torque tube front nut to 140 to 160 pound-inches. Lockwire tube nuts.

(5) On JT3D-1 Douglas, JT3D-3 Douglas, and JT3D-3B Douglas engines, install packing and retainer on each end of rear breather tube and then attach tube to tee on intermediate case and elbow on diffuser case with tube nuts. Secure tube with clip to bracket on front flange of diffuser case. Torque tube rear nut on elbow. Torque tube front nut on tee to 140 to 160 pound-inches. Lockwire tube nuts.

D. Breather Tubes and Connections - Installation (JT3D-1-MC6)

(1) Engines not incorporating gearbox breather tubes.

(a) Using new packing, install breather tee on its pad in upper left quadrant of intermediate case. Secure tee with bolts and washers. Torque and lockwire bolts.

(b) Using new gasket, install breather elbow on its pad at approximate 12 o'clock position on diffuser case. Install clip bracket with longer bolt in top and left holes in elbow flange. Use short bolt in right hole in elbow flange. Torque and lockwire bolts.

(c) Position flange of front breather tube to flange of connector at 12 o'clock position on inlet case and insert rear end of tube into tee on intermediate case. Secure tube to tee with tube nut and to connectors with bolts and locknuts. Torque and lockwire flange nuts and tube nut.

(d) Install tube nuts on plain end of rear breather tube so that threads of nuts are positioned outward; then install ferrule and packing on plain end of tube and packing and retainer on ferruled end. Position tube to tee on intermediate case and elbow on diffuser case; then secure it with tube nuts. Tighten rear tube nut on elbow to recommended torque. Torque tube front nut on tee to 140 to 160 pound-inches. Lockwire tube nuts.

(2) Engines incorporating gearbox breather tubes.

(a) Using new packing, install breather tee on its pad in upper left quadrant of intermediate case. Secure tee with bolts and washers. Torque and lockwire bolts.

(b) Position flange of front breather tube to flange of connector at 12 o'clock position on inlet case and insert rear end of tube into tee on intermediate case. Secure tube to tee with tube nut and to connector with bolts and locknuts. Torque and lockwire flange and tube nut.

(c) Install tube nut on plain end of rear breather tube so that threads of nut are positioned outwards and then install ferrule, packing, and retainer on plain end of tube and new gasket on other end of tube. Position tube from tee on intermediate case to pad at approximately 12 o'clock location on diffuser case. Secure rear flange of tube to diffuser case pad with bolts; installing clip bracket on longer bolts in top and left holes in flange. Torque and lockwire bolts. Torque tube front nut at tee to 140 to 160 pound-inches.

(d) Install connector with new packing on accessory and component drive gearbox right pad cover.

(e) Using new packing and retainer on lower end of gearbox breather tube, attach tube to connector on right gearbox pad cover and tee rear breather tube. Torque and lockwire tube nuts.

(f) Secure gearbox breather tube with clip to bracket diffuser case right anti-icing air pad. Secure rear breather tube with clip to bracket on diffuser case front flange.

OIL SYSTEM - MAINTENANCE PRACTICES

E. Breather Tubes and Connections - Installation (JT3D-1-3B-DL)

(1) Using new gasket, install breather tube elbow on its pad at top of diffuser case. Secure elbow with bolts and tighten them to recommended torque. Lockwire bolts.

(2) Using new packing, install plug in front breather elbow and torque plug. Install new packing on elbow and attach elbow to intermediate case between mounting flanges at approximately two o'clock position with bolts. Plug should be facing up and elbow to rear. Torque and lockwire bolts.

(3) Install new packing and retainer on front end of breather tube and position tube between two elbows. Torque and lockwire tube rear nut. Torque tube front nut to 140 to 160 pound-inches. Lockwire tube nut and elbow plug.

3. Removal/Installation of the Oil Scavenge Tubes

NOTE: Tag or note the location of all clips and/or clamps to assure their reinstallation in the same location at assembly.

A. Oil Scavenge Tubes - Removal (JT3D-1 Douglas, JT3D-3 Douglas and JT3D-3B Douglas)

(1) Unfasten the No. 6 bearing oil suction rear tube nut securing it to the No. 6 bearing oil suction intermediate tube; then remove the bolts securing the flange of the tube to the scavenge pad at the approximate 6 o'clock position on the rear of the turbine exhaust case and remove the tube.

(2) Unfasten and remove the clip securing the No. 6 bearing intermediate tube to the front exhaust case mount ring at the approximate 6 o'clock position and the clips securing the tube to the turbine exhaust case front flange and turbine nozzle case front flange. Loosen the nut securing the No. 6 bearing oil suction intermediate tube to the No. 6 bearing oil suction front tube; then remove the intermediate tube.

(3) Remove the clip securing the No. 6 bearing oil suction front tube to the bracket in the combustion chamber outer front case front flange.

(4) Unfasten the tube nut securing the No. 6 bearing oil suction front tube to the elbow on the left rear of the gearbox; then draw the tube forward through the fireseal and remove the tube.

(5) Disconnect the clip securing the No. 4 bearing-to-gearbox oil suction tube to the clamp on the diffuser case front flange (lower left segment).

OIL SYSTEM - MAINTENANCE PRACTICES

(6) Loosen the nuts securing the No. 4 bearing-to-gearbox oil suction tube to the elbow in the lower left quadrant of the diffuser case and to the elbow on the right front of the gearbox assembly and remove the tube.

NOTE: This tube cannot be removed until the fuel control, fuel pump, and airframe accessories installed on the gearbox assembly are removed.

(7) Remove the locknuts securing the boss of the manifold assembly to lower front center connection on the gearbox assembly. Disconnect the No. 1 Bearing oil suction tube nut from the manifold. Remove the bolts and nuts securing the manifold flange to the oil suction adapter located at the forward 6 o'clock location of the intermediate case. Remove the manifold.

(8) Remove the clip securing the No. 1 bearing oil suction tube to the front compressor front case rear flange; then remove the bolts and locknuts securing the flange of the No. 1 bearing oil suction tube to the connection at the 7 o'clock location of the inlet case. Remove the tube.

B. Oil Scavenge Tubes - Removal (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6, and JT3D-1-MC7)

(1) Unfasten the No. 6 Bearing oil suction rear tube at the elbow, approximately the six o'clock position, on the rear of the turbine exhaust case and the nut securing the tube to the No. 6 Bearing oil suction intermediate tube; then withdraw the tube rearward through the shielding tube in the exhaust case mount rings and remove the tube.

(2) Loosen the nut securing the No. 6 bearing oil suction intermediate tube to the No. 6 bearing oil suction front tube; then remove the intermediate tube.

(3) Remove the bolts and nuts securing the No. 6 bearing oil suction front tube retaining boss to the fireseal.

(4) Unfasten the tube nut securing the No. 6 Bearing front tube to the elbow on the left rear of the gearbox; then draw the tube forward through the fireseal, and remove the tube. Remove the fireseal boss from the tube.

(5) Loosen the nuts securing the No. 4 bearing-to-gearbox oil suction tube to the elbow in the lower left quadrant of the diffuser case and to the elbow on the right front of the gearbox assembly and remove the tube.

NOTE: This tube cannot be removed until the fuel control, fuel pump, and airframe accessories installed on the gearbox assembly are removed.

OIL SYSTEMS - MAINTENANCE PRACTICES

(6) Remove the locknuts securing the boss of the manifold assembly to the lower front center connection on the gearbox assembly. Disconnect the No. 1 bearing oil suction rear tube nut from the manifold. Remove the nuts and bolts securing the manifold flange to the oil suction adapter located at the forward 6 o'clock location of the intermediate case. Remove the manifold.

(7) Unfasten the nuts at the No. 1 bearing oil suction rear and front tubes; then remove the No. 1 bearing oil suction intermediate tube.

(8) Remove the clips securing the No. 1 bearing oil suction rear tube to the clamps on the front compressor rear case flange. Remove the No. 1 bearing oil suction rear tube.

(9) Unfasten the bolts and locknuts securing the flange of the No. 1 bearing front tube to the connection at the 7 o'clock location on the inlet case; then remove the clips securing the tube to the brackets on the fan discharge case front flange. Remove the tube.

C. Oil Scavenge Tubes - Installation (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7)

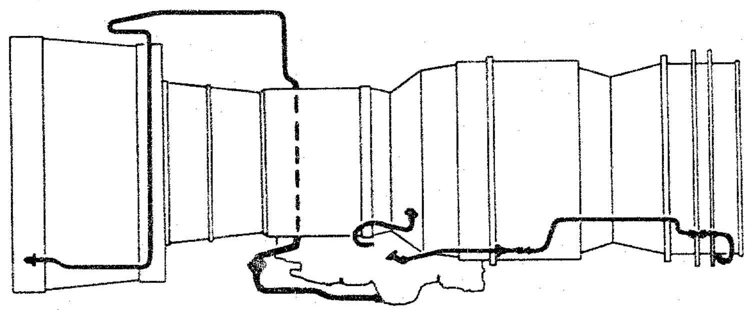
See Figure 203.

(1) Coat new packing with engine oil and install it in flanged end of No. 1 bearing oil scavenge front tube. Position tube to connection at seven o'clock location on inlet case and secure it with locknuts and bolts. Torque bolts. Secure tube clips to brackets on fan discharge case front flange in locations noted at disassembly. Torque clip screws.

(2) Position No. 1 bearing oil scavenge rear tube on right side of front compressor rear case and secure it to clamps on front compressor case rear flange in locations noted at disassembly. If No. 1 bearing oil pressure rear tube is installed, secure scavenge tube to pressure tube with clips in location noted at disassembly. Torque clip screws.

<u>NOTE</u>: If pressure tube is not installed, retaining clips may be installed at time of its assembly.

(3) Position No. 1 bearing oil scavenge intermediate tube to No. 1 bearing oil scavenge front and rear tubes and secure it with nuts. Torque and lockwire nuts.



Oil Scavenge System Tubing
(JT3D-1 Boeing, D-3 Boeing, D-3B Boeing, MC-6 and MC-7)
Figure 203

(4) Coat new packings with engine oil and install them on both ends of compressor intermediate front bearing oil scavenge tube. On gearbox end of tube assembly, install boss flanged end out; then coat new packing with engine oil and install it in groove of boss. On tube connector end of tube assembly, install bushing flanged end in; then coat new packing with engine oil and install it on bushing. Position assembled tube assembly to gearbox assembly connection (lower front center) and to leg of oil tube connector. Secure tube assembly to gearbox with locknuts and to oil tube connector with bolts, washers (under boltheads) and locknuts. Torque bolts and locknuts. Connect nut of No. 1 bearing oil scavenge rear tube to tee connection on tube assembly. Torque and lockwire tube nuts.

(5) Using new packing coated with engine oil, secure compressor rear bearing to gearbox tube elbow to right front of gearbox with bolts. Torque and lockwire bolts.

(6) Using new packing coated with engine oil, position diffuser case elbow facing down to lower left quadrant of diffuser case. Secure elbow with bolts; installing airframe bracket assembly on two longer top bolts. Torque and lockwire bolts.

OIL SYSTEMS - MAINTENANCE PRACTICES

(7) Coat new packings with engine oil and install them on both ends of No. 4 Bearing-to-gearbox oil scavenge tube; then install retainers on both ends. Position tube to elbow in left lower quadrant of diffuser case and to elbow on right front of gearbox assembly. Secure tube with nuts. Torque tube nuts 140 to 160 pound inches. Lockwire tube nuts.

(8) Install nut, ring and new packing coated with engine oil on No. 6 bearing oil scavenge tube elbow and install elbow in left rear of gearbox. Torque and lockwire nut.

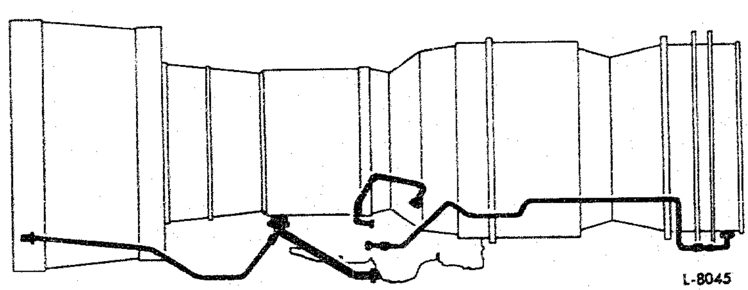
(9) Coat new packing with engine oil; then install it in its groove on sleeve of No. 6 bearing oil scavenge front tube. Place boss on tube (flange face forward) and slide it over tube and sleeve. Secure boss to fireseal using bolts and locknuts. See Figure 205. Torque bolts. Secure tube to elbow on left rear of gearbox with tube nut. Torque and lockwire tube nuts.

(10) Position No. 6 bearing oil scavenge intermediate tube to front tube and secure it with nut. Install clips at turbine nozzle case front flange and turbine exhaust case front flange.

(11) Install No. 6 bearing oil scavenge rear tube forward through shielding tube in exhaust case mount ring and secure tube to intermediate tube with nut; then secure rear of tube to elbow on scavenge pad at approximate six o'clock position on rear of turbine exhaust case. Torque and lockwire tube nuts.

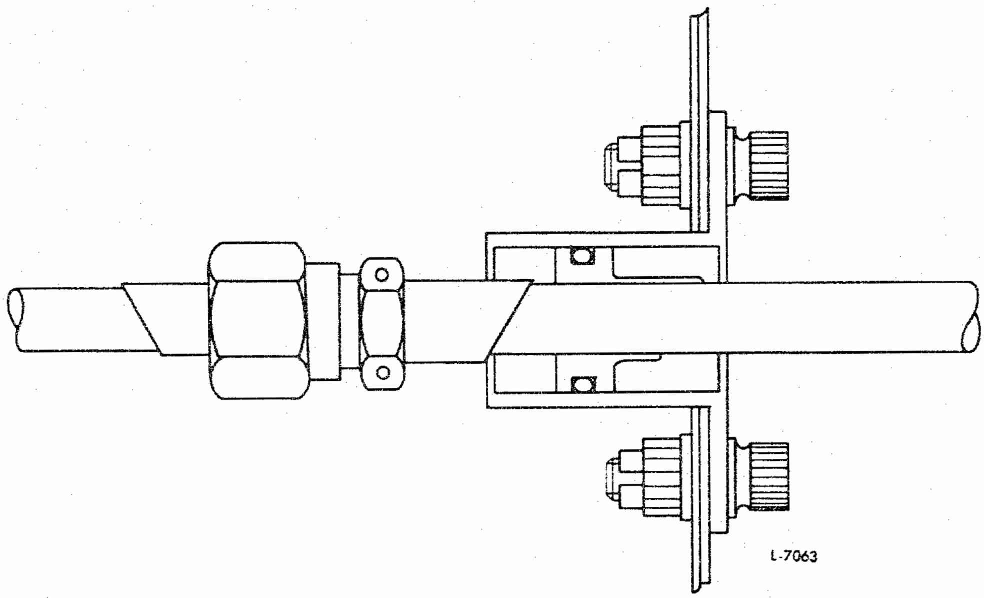
D. Oil Scavenge Tubes - Installation (JT3D-1 Douglas, JT3D-3 Douglas, JT3D-3B Douglas, and JT3D-3B-DL Engines)

See Figure 204.



Oil Scavenge System Tubing
(JT3D-1 Douglas, D-3 Douglas, and D-3B Douglas)
Figure 204

OIL SYSTEMS - MAINTENANCE PRACTICES



Fireseal Mounting Arrangement (JT3D-1 Boeing, D-3 Boeing, D-3B Boeing, JT3D-1-MC6, JT3D-1-MC7)
Figure 205

(1) Coat new packing with engine oil and install it in flanged end of No. 1 bearing oil scavenge tube. Position tube to connection at seven o'clock location on inlet case and secure it with locknuts and bolts. Torque bolts. Secure tube clip to bracket on rear flange of front compressor case in location noted at disassembly. Torque clip screw.

(2) Coat new packings with engine oil and install them on both ends of manifold assembly. On gearbox end of manifold assembly, install boss flanged end out; then coat new packing with engine oil and install it in groove of boss. On oil adapter assembly end of manifold assembly, install bushing flanged end in; then coat new packing with engine oil and install it on bushing. Position assembled manifold to gearbox assembly connection (lower front center) and to leg of oil adapter assembly. Secure manifold assembly to gearbox assembly with locknuts and to oil adapter assembly with bolts, washers (under boltheads) and locknuts. Torque bolts and locknuts. Connect No. 1 bearing oil scavenge tube to "Y" connection of manifold assembly. Torque and lockwire tube nuts.

(3) Coat new packings with engine oil and install them on both ends of No. 4 bearing-to-gearbox oil scavenge tube; then install retainers on both ends. Position tube to elbow in left lower quadrant of diffuser case and to elbow on right front of gearbox assembly. Secure tube with nuts. Torque and lockwire nuts.

(4) Install clip securing No. 4 bearing-to-gearbox oil scavenge tube to clamp on diffuser case front flange (lower left segment).

(5) Install seal on sleeve of No. 6 bearing oil scavenge front tube and slide tube rearward through hole in fireseal. Torque bolts. Secure tube to elbow on left rear of gearbox with tube nut. Torque nuts. Install clip securing No. 6 bearing oil scavenge front tube to bracket on combustion chamber outer front case front flange.

(6) Position No. 6 bearing oil scavenge intermediate tube to front tube and secure it with nut. Install clips at turbine nozzle case front flange and turbine exhaust case front flange. Install clip to front exhaust case mount ring at approximate six o'clock position. Secure clips with screws and nuts. Torque tube nut and clip screws. Lockwire the tube nut.

(7) Position No. 6 bearing oil scavenge rear tube to intermediate tube and secure it with tube nut; then secure flange of tube to scavenge pad at approximate six o'clock position on rear of turbine exhaust case with bolts. Torque bolts and tube nut. Lockwire tube nut.

4. Removal/Installation of the Oil Adapter and Filter-to-Adapter Oil Pressure Tube

A. Removal

(1) Loosen the nut securing the filter-to-adapter oil pressure tube at the oil filter housing; then loosen the nut at the oil adapter and remove the tube.

(2) Remove the bolts and locknuts securing the oil adapter to the intermediate case mount ring.

(3) On the JT3D-1 (Boeing), JT3D-1-MC6, and JT3D-1-MC7, remove the two internal and two external spacers positioning the adapter in the intermediate case mount ring area or for the JT3D-1 (Douglas), remove the four internal spacers.

NOTE: On the JT3D-1 (Boeing), JT3D-1-MC6, and JT3D-1-MC7, the internal spacers are used on the adapter arms adjacent to the oil filter housing. If fuel deicing equipment (optional) is installed, the external spacers are replaced by the lugs of the fuel de-icing filter.

(4) Remove the oil adapter.

OIL SYSTEM - MAINTENANCE PRACTICES

B. Installation

(1) Coat a new packing with engine oil and install it in the groove of the compressor intermediate bearing oil pressure tube flange in the forward 6 o'clock location of the intermediate case.

(2) Coat new packings with engine oil and install them in the groove of the nipple and the outside rim of the mating lip of the oil adapter.

(3) Position the oil adapter to the intermediate case inserting the nipple in the compressor intermediate bearing oil pressure tube and aligning the bolt holes of the mount rings, filter housing, and adapter.

NOTE: The oil filter housing must be in position prior to the installation of the oil adapter.

(4) For the JT3D-1 (Boeing), JT3D-1-MC6, and JT3D-1-MC7, install the internal spacers (small ID inward) from the inside through the legs of the oil adapter and then through the legs of the oil filter housing. Secure the build-up by inserting the bolts through the mount rings of the intermediate case and installing the nuts on the inside of the legs. Tighten the bolts and nuts to the recommended torque.

NOTE: Install a bracket under the bolt head of the rear bolt to support a fuel tube clip.

(5) For the JT3D-1 (Boeing), JT3D-1-MC6, and JT3D-1-MC7, position the external spacers between the remaining legs of the oil adapter (left side) and the intermediate case mount rings. Install the bolts and locknuts in the manner previously described.

(6) For the JT3D-1 (Douglas), install the larger internal spacers and the bolt and nuts in the manner outlined in step (4). Install the smaller internal spacers (small ID in) from the inside through the remaining legs of the oil adapter (left side). Install the bolts and locknuts in the manner previously described.

(7) Install the tube nuts on the filter-to-adapter oil pressure tube so that the threads of the nuts are outward at both ends. Install a ferrule on the plain end; then coat new packing with engine oil and install one on each end. Install a retainer in both ends of the tube. Position the tube (plain end) in the connector on the filter housing; then install the other end in the connector of the oil adapter. Tighten the tube nuts to the recommended torque and lockwire.

OIL SYSTEM - MAINTENANCE PRACTICES

5. Removal/Installation of the Oil Pressure Tubes

NOTE: Tag or note the location of all clips and/or clamps to assure their reinstallation in the same location at assembly.

A. Pressure Oil Tubes - Removal

(1) If installed, remove the clip securing the thermocouple harness to the No. 6 bearing oil pressure rear tube.

(2) Loosen the nut securing the No. 6 bearing oil pressure rear tube to the elbow at the 3 o'clock position on the exhaust case and loosen the nut on the rear end of the No. 6 bearing oil pressure intermediate tube; then remove the rear tube by withdrawing it rearward from the shielding tube located between the exhaust case mount rings.

(3) If installed, remove the clips securing the thermocouple harness lead (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7) to the No. 6 bearing oil pressure intermediate tube and the clip assembly securing the tube and the harness lead (JT3D-1 Douglas, JT3D-3 Douglas, JT3D-3B Douglas) to the bracket at the approximate 5 o'clock location on the combustion chamber outer rear case rear flange.

(4) Loosen the nut securing the No. 6 bearing oil pressure front tube to the intermediate tube; then remove the No. 6 bearing oil pressure intermediate tube.

(5) Loosen the nut securing the No. 6 bearing oil pressure front tube to the adapter at the approximate 5 o'clock position on the diffuser case; then remove the tube from the sleeve on the fireseal by turning it and pulling it forward out of the sleeve.

(6) Loosen the nuts securing the gearbox-to-rear bearings tube at the previously mentioned adapter assembly and at the manifold assembly mounted on the right side of the gearbox assembly. Remove the tube.

(7) Loosen the nut securing the manifold assembly to the top rear-facing connection on the filter housing and remove the nuts securing the manifold assembly to the gearbox assembly. Remove the manifold assembly.

(8) Remove the clip assembly; then loosen the nut securing the gearbox-to-oil filter housing tube to the bottom rear-facing connection on the oil filter housing and remove the nuts securing the tube flange to the pressure boss on the left front of the gearbox assembly. Remove the tube.

(9) On the JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7, loosen the nuts securing the No. 1 bearing oil pressure intermediate tube to the No. 1 bearing oil pressure front and rear tube; then remove the No. 1 bearing oil pressure intermediate tube.

(10) On the JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7, remove the clip assemblies securing the No. 1 bearing pressure oil rear tube to the No. 1 bearing scavenge oil rear tube.

(11) On the JT3D-1 and JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7, loosen the nut securing the No. 1 bearing oil pressure rear tube to the top forward-facing connection on the oil filter housing and remove the tube.

(12) On the JT3D-1 and JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7, remove the clips securing the No. 1 bearing oil pressure front tube to the front flange of the fan discharge case.

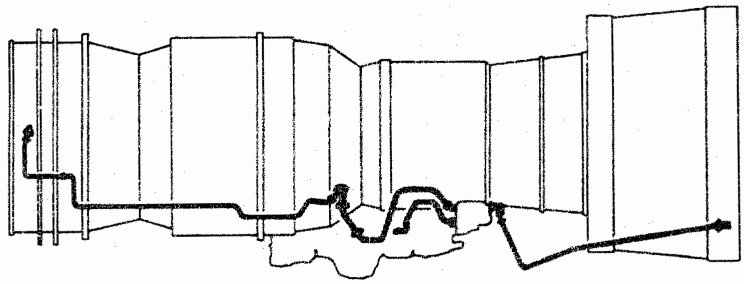
(13) On the JT3D-1 and JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7, remove the bolts securing the flange of the No. 1 bearing oil pressure front tube to the connection on the approximate 5 o'clock location on the inlet case. Remove the tube.

(14) On the JT3D-1 Douglas, JT3D-3 Douglas and JT3D-3B Douglas, remove the clip securing the No. 1 bearing oil pressure tube to the bracket on the front compressor case rear flange; then unfasten the nut at the filter housing connector (elbow) and remove the bolts and locknuts securing the tube flange to the connection at the 5 o'clock location of the inlet case. Remove the tube.

B. Pressure Oil Tubes - Installation (JT3D-1 Douglas, JT3D-3 Douglas, JT3D-3B Douglas and JT3D-3B-DL Engines)

See Figure 206.

(1) Coat new packing with engine oil and install it in flanged end of No. 1 bearing oil pressure tube, and coat new packing and retainer with engine oil and install them in rear end of tube. Position No. 1 bearing oil pressure tube to connection at five o'clock location of inlet case and connector (elbow) on filter housing. Secure tube to connector with tube nut and to inlet case connection flange with bolts and locknuts. Tighten tube nut and the bolts and locknuts to recommended torque. Lockwire tube nut. Reinstall clip to bracket on front compressor front case rear flange. Torque clip screw and nut.



Oil Pressure System Tubing
(JT3D-1 Douglas, D-3 Douglas, and D-3B Douglas)
Figure 206

(2) Install new seal coated with engine oil and retainer on ferruled tube end of gearbox-to-oil filter housing tube and new seal on flanged end; then position tube to lower rear-facing connection on filter housing with the flanged end on pressure boss on right front of gearbox assembly. Secure flanged end with the nuts and other end with tube nut. Tighten nuts and tube nut to recommended torque. Lockwire tube nut.

(3) Install new seal coated with engine oil and retainer on ferruled tube end of manifold assembly and new seal on manifold end. Position manifold assembly tube end to top rear-facing connection on filter housing and manifold end to boss on right side of gearbox housing. Secure manifold assembly to gearbox assembly with nuts and to filter housing with tube nut. Tighten nuts and tube nut to recommended torque. Lockwire tube nut.

(4) Install clip assembly securing gearbox-to-filter housing tube to manifold at location noted at disassembly. Torque screw and nut.

(5) Install new packings coated with engine oil and retainers on both ends of gearbox-to-rear bearings tube and install tube in large connection on adapter located at approximate five o'clock position on diffuser case and connection on previously installed manifold. Torque and lockwire tube nuts.

(6) Install new seal coated with engine oil on external ferrule on No. 6 bearing oil pressure front tube; then install tube rearward through sleeve in fireseal and install tube to previously mentioned adapter and secure it with tube nut. Torque and lockwire nut.

(7) Install clip on the No. 6 bearing oil pressure front tube in location noted at disassembly. Secure clip with screw and nut. Torque screw and nut.

(8) Position No. 6 bearing oil pressure intermediate tube to front tube and secure it with tube nut; then install clip to bracket on combustion chamber outer rear case rear flange. Tighten tube nut and clip screws and nuts to recommended torque. Lockwire tube nuts.

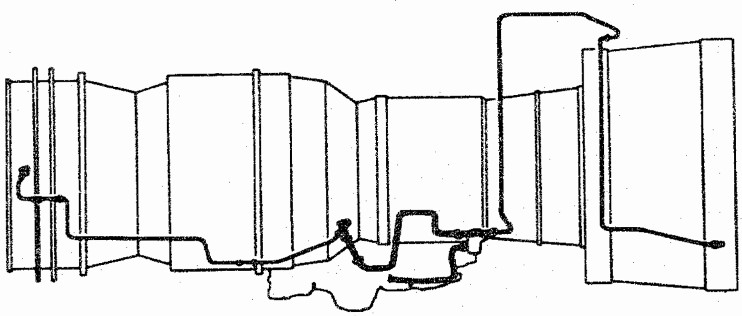
(9) Insert No. 6 bearing oil pressure rear tube forward through shield tube in turbine exhaust case mount ring; then secure rear tube to intermediate tube and to elbow on the three o'clock position of exhaust case with tube nuts. Torque and lockwire nuts.

(10) Secure thermocouple harness to No. 6 bearing oil pressure rear tube with clip assembly at location noted at disassembly.

C. Pressure Oil Tubes - Installation (JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7)

See Figure 207.

(1) Install clips on No. 1 bearing oil pressure front tube in location noted at disassembly.



Oil Pressure System Tubing
(JT3D-1 Boeing, D-3 Boeing, D-3B Boeing and MC6)
Figure 207

OIL SYSTEM - MAINTENANCE PRACTICES

(2) Coat new packing with engine oil and install it in flanged end of No. 1 bearing oil pressure front tube; then secure tube to connector at five o'clock location of inlet case with bolts and locknuts. Torque bolts and locknuts. Secure clips to clamps on front flange of the fan discharge case with screws and nuts. Torque screws and nuts.

(3) Position No. 1 bearing oil pressure rear tube to nipple on top forward face of strainer housing and secure it with tube nut. Torque and lockwire nut.

(4) Fasten clip assemblies securing No. 1 bearing oil pressure rear tube to No. 1 bearing oil scavenge rear tube in locations noted at disassembly.

(5) Position No. 1 bearing oil pressure intermediate tube to front and rear tubes and secure it with tube nuts. Torque and lockwire nuts.

(6) Install new seal coated with engine oil and retainer on ferruled tube end of gearbox-to-oil strainer housing tube and new seal on flanged end; then position tube to lower rear-facing connection on strainer housing with flanged end on pressure boss on right front of gearbox assembly. Secure flanged end with nuts and other end with tube nut. Tighten flange nuts t recommended torque. Torque the tube nut and lockwire.

NOTE: On configuration incorporating a tee on gearbox-to-oil strainer housing tube, install a plug with new packing in tee and torque plug.

(7) Install new seal coated with engine oil and retainer on ferruled tube end of strainer-to-gearbox manifold assembly and new seal on flanged end. Position manifold assembly tube end to top rear-facing connection on strainer housing and flanged end to boss on right side of gearbox housing. Secure manifold assembly to gearbox assembly with nuts and to filter housing with tube nut. Torque flange nuts. Torque tube nut to 200 to 220 pound inches, and lockwire.

(8) Install clip assembly securing manifold assembly to fuel tube using screw, spacer, and the nut. Torque screw.

(9) Using new gasket, install rear bearing oil pressure adapter to pad on diffuser case at approximate five o'clock position with large connection facing down. Install bolts with airframe bracket on rearmost bolt. Torque and lockwire bolts.

OIL SYSTEM - MAINTENANCE PRACTICES

(10) Install tube nuts on plain end of gearbox to rear bearing oil pressure tube so that threads of nuts are positioned outward and then install ferrule on plain end of tube. Install new packings coated with engine oil and retainers on both ends of the tube and attach tube assembly to oil filter to gearbox return manifold and large connection of rear bearing oil pressure adapter on diffuser case. Torque tube nuts to 140 to 160 pound inches, and lockwire.

(11) Install new seal coated with engine oil on external ferrule on No. 6 bearing oil pressure front tube; then install tube rearward through sleeve in fireseal and install tube to previously mentioned adapter and secure it with tube nut. Torque and lockwire nut.

(12) Position No. 6 bearing oil pressure intermediate tube to front tube and secure it with tube nut; then install clip assemblies to thermocouple lead. Torque tube nut, clip screws and nuts. Lockwire tube nuts.

(13) Insert No. 6 bearing oil pressure rear tube forward through shield tube in turbine exhaust case mount ring; then secure rear tube to intermediate tube and to elbow on three o'clock position of exhaust case with tube nuts. Torque and lockwire nuts.

(14) Secure thermocouple harness to No. 6 bearing oil pressure rear tube with clip assembly at location noted at disassembly. Using screw and nut, torque clip assembly.

FUEL COOLANT OIL COOLER - MAINTENANCE PRACTICES

1. Removal/Installation of the Fuel Oil Cooler

NOTE: The oil cooler for the JT3D-1 (Douglas), and JT3D-3 (Douglas) engines is airframe supplied.

A. Removal

(1) Remove the nuts and gaskets securing the fuel-oil cooler bracket to the diffuser case and to the cover of the right fluid drive on the gearbox assembly.

(2) Remove the fuel-oil cooler and brackets.

B. Installation (JT3D-1 Boeing, D-3 Boeing, D-3B Boeing, MC6 and MC7)

(1) Position the fuel-oil cooler and brackets to the studs on the diffuser case and the right fluid drive cover on the gearbox assembly. Secure them with gaskets and nuts.

(2) Torque nuts.

C. Installation (JT3D-3B-DL)

(1) Position fuel-oil cooler to bracket on right fluid drive cover bracket of gearbox assembly. Secure with bolts and nuts. Secure oil cooler flange to bracket located at 9 o'clock position on diffuser case front flange. Cooler flange shall be on outside of bracket with bolts and washer installed from bracket side. Place spacer between bracket and cooler; then install nuts and bolts. Torque bolts.

OIL DRAIN VALVE - DESCRIPTION AND OPERATION

General

Oil drain valve is located at bottom of oil tank. Valve is held in closed position by constant spring force exerted on handle. Manually rotating handle ninety degrees in counterclockwise direction opens valve. Valve in this position will allow oil to drain from tank. Tension of spring will automatically return valve to closed position when handle is released (started from open position detent).

OIL DRAIN VALVE - MAINTENANCE PRACTICES

1. Removal/Installation of Oil Drain Valve

A. Removal

(1) Cut the lockwire and loosen the locknut which secures the oil drain valve to the oil tank adapter.

(2) Unscrew the drain valve and remove it from the adapter.

B. Installation

(1) Screw the threaded end of the drain valve into the oil tank adapter and tighten the locknut to the recommended torque.

(2) Lockwire the locknut.

OIL TANK - DESCRIPTION AND OPERATION

General

NOTE: The oil tank for the JT3D-1 (Douglas) and JT3D-3 (Douglas) is airframe supplied.

Description (JT3D-1 Boeing, D-3 Boeing, D-3B Boeing, MC6 and MC7)

Engine oil tank is mounted in upper right quadrant of intermediate case. It is strapped to engine at this location by two straps attached to brackets on front and rearflanges of intermediate case. These straps support tank at middle and lower areas of tank. Strips of resilient material, serving as vibration isolators, are installed between tank and engine and tank and straps. These strips are of silicone rubber. Tank has capacity of 6.0 gallons, with minimum usable quantity of 3.25 gallons under all operating conditions. It is constructed of stainless steel supported by stiffening posts welded to ferrules. Internally, tank incorporates a deaerator which is so located that outlet is submerged even at low tank levels to prevent deaeration of oil. A connection at upper forward side location permits insertion of breather tube. On outside face of tank at upper forward position, a filler hole with filler cap is located. On lower rearward side of tank are two connections. Oil tank lower connection is blanked-off. At bottom of tank are oil out and oil drain connections a valve is installed on drain connection. To aid in cleaning and inspection, there are two holes closed by plugs. The largest of these is at bottom of tank adjacent to oil out connection, while smaller is located in upper middle of tank adjacent to filler connection.

Description (JT3D-3B Douglas and JT3D-3B-DL)

Engine oil tank is mounted on upper left quadrant of front compressor case (Fan case) it is strapped to engine at this location by two straps attached to brackets on front and rearflanges of front compressor case (Fan case). These straps support tank at upper and lower section. Strips of resilient material (silicone rubber) serving as vibration isolators are installed between tank and engine and tank and straps. Tank has a capacity of 5.2 gallons, with minimum usable quantity of 2.50 gallons under all operating conditions. It is constructed of stainless steel supported by stiffening posts welded to ferrules. Internally, tank incorporates flow deaerator which is so located that outlet is submerged even at low tank levels to prevent reaeration of oil. A connection at upper rearward side of tank permits attachment of oil scavenge-to-cooler tube. Two bosses at extreme upper portion of oil tank permit attachment of breather tubes. A valve is installed at rear bottom portion of tank. There is also one boss which is plugged and one boss used to connect oil tank-to-pump supply tube. On outside face of tank at upper rearward position, a filler hole with filler cap is located.

OIL TANK - DESCRIPTION AND OPERATION

1. Removal/Installation of the Oil Tank JT3D-1 Boeing, JT3D-3 Boeing, JT3D-3B Boeing, JT3D-1-MC6 and JT3D-1-MC7)

NOTE: The oil tank for the JT3D-1 (Douglas) and JT3D-3 (Douglas) is airframe supplied.

A. Removal

(1) Remove the nuts and washers securing the upper strap assembly to the oil tank upper mount brackets. Remove the strap assembly.

(2) With the aid of an assistant, support the oil tank; then remove the nuts and washers securing the lower strap assembly to the oil tank lower mount brackets. Remove the strap; then remove the tank.

B. Installation

(1) With the aid of an assistant, position the oil tank to the mount brackets on the right side of the engine; then install the tee pins of the lower strap assembly in the strap holes in the lower brackets. Secure the strap with the washers and nuts. Tightening oil tank bracket nuts until just before nut begins to tension strap. Check torque at this point then continue tightening until 5 to 7 pound inches above previously checked torque is reached.

2. Removal/Installation of Oil Tank (JT3D-3B Douglas and JT3D-3B-DL)

A. Removal

(1) Remove lockwire, nuts and washers securing rear portion of upper strap to bracket; then remove cotterpin and pin securing forward portion of strap to bracket. Remove strap assembly.

(2) With aid of an assistant, support oil tank; then repeat step (1) for removal of lower strap. Remove oil tank.

B. Installation

(1) With aid of an assistant, position oil tank to mount brackets located on left side of engine between inlet case rear flange and fan discharge case front flange.

(2) Install tee pins through oil tank stop and lower bracket. Secure bracket with washer and two nuts (thick nut contacting washer). Tighten inner nut to torque of 15 to 20 pound inches. Torque outer nut. Repeat same procedure for upper bracket.

LIST OF EFFECTIVE PAGES

R/ = Revised D/ = Deleted

The List of Effective Pages records not only each page of subject revision but also each previously issued page which is still current. Blank pages and pages which are no longer current do not appear on this list. If there is any question about the currency of the recipient's copy, it is recommended that each page of the manual be checked off against this List of Effective Pages. Any page which does not check out with this list, either by number or by date, shall be discarded.

CHAPTER/ SECTION		PAGE	DATE	CHAPTER/ SECTION	PAGE	DATE	CHAPTER/ SECTION	PAGE	DATE
Tab Separator - Water Injection									
List of Effective Pages - Water Injection									
	R/	A	Dec. 1/67						
Table of Contents - Water Injection									
82		1	Dec. 15/63						
82-0	R/	1	Dec. 1/67						
		2	Aug. 1/62						
		201	Dec. 15/63						
		202	Dec. 15/63						
82-1-1		1	Aug. 1/62						
		201	Dec. 15/63						
82-2-1		1	Aug. 1/62						
		201	Dec. 15/63						
82-3-1		1	Aug. 1/62						
		201	Dec. 15/63						
82-4-1		1	Aug. 1/62						
		201	Dec. 15/63						

TABLE OF CONTENTS

CHAPTER 82 WATER INJECTION

WATER INJECTION SYSTEM - DESCRIPTION AND OPERATION

General

An optional water injection system is installed on some JT3D-3 Boeing and JT3D-3B Boeing engines and on the JT3D-1-MC6 QANTAS engines. The system functions to increase engine thrust by means of two basic principles. The first involves the fact that engine thrust is increased with increasing mass air flow. Hence, by spraying water into the air stream the mass of material flowing through the engine is increased and, consequently, the thrust is increased. The second principle relates to the cooling effect of water injected into the engine gas path. Turbo engines are normally limited in their thrust output by the fact that further increase of fuel flow would result in hot section temperatures beyond values which the parts are capable of withstanding. Since the injection of water effectively reduces hot section temperatures, fuel flows may be increased and greater thrusts thereby obtained. Since thrust increase is particularly desirable at take-off when an aircraft engine is called upon for its greatest output of power, the water injection system is designed to function only at high engine power.

The engine water injection system injects the water into the diffuser case. Its contribution to thrust increase depends largely upon the cooling principle, which permits the higher fuel flow.

Description and Operation

The description and operation of the water injection system can most easily be explained by tracing the flow of water from the tank to its discharge point in the engine.

Placement, location, and number of system components may vary with the aircraft installation, but generally the system will follow the same scheme. The system is designed for operation at ambient temperatures above 20°F (-7°C).

Water from the aircraft tank system is directed to the shut-off valve which governs the flow to the water injection control. This shut-off valve is alerted by the actuation of a cockpit switch, and the valve opens or closes upon receipt of an electrical signal from the fuel control water injection switch. When a power lever advance creates a predetermined position, this switch supplies an "open" signal to the shut-off valve. Conversely, when the position is reduced to below the water turn-on point, the switch supplies a "close" signal to the shut-off valve.

Water from the open shut-off valve flows to the water injection control. Since the water injection system is only used when power settings are at or near their maximum, the control does not vary or meter water flow. Instead it maintains a constant pressure head across a fixed orifice, thereby maintaining a constant water flow to the engine.

WATER INJECTION SYSTEM - DESCRIPTION AND OPERATION

Water from the control passes through a check valve and is then directed to a split manifold from which it is sprayed into the diffuser case. When the water injection system is not in use, the check valve prevents high temperature compressor discharge air from backing up into the water injection system plumbing where it might damage the controls or valves. A drain valve located downstream of the water shut-off valve drains the engine water lines when the injection system is turned off, thus preventing water from freezing in these lines.

WATER INJECTION SYSTEM - MAINTENANCE PRACTICES

1. Removal/Installation of Water Injection Tubing

NOTE: Tag or note the location of all clamps and clips to assure their reinstallation in the same position at assembly.

A. Removal

(1) Remove the clips securing the upper and lower signal tubes on the right side of the diffuser case.

(2) Loosen the nuts securing the tubes to each other, to the connector on the water injection and to the connection on the fuel control. Remove the tube.

(3) Loosen the nuts; then remove the control-to-check valve supply tube.

(4) Disconnect the water injection check valve and attached manifold connector from the right and left water injection manifold assemblies.

(5) Remove the nuts securing the clip assemblies to the right and left water injection manifold assemblies.

(6) Disconnect the water injection manifold tube assemblies from the right and left manifold assemblies and remove the manifolds.

(7) Note the location of the curled water injection tube assemblies; then remove the bolts securing the tube assemblies to the pads on the diffuser case and remove brackets, tube assemblies, and gaskets.

B. Installation

(1) Place gaskets on the pads on the diffuser case; then position the curled water injection tube assemblies on the pads. Install the brackets in the locations noted at disassembly; then secure the tube assemblies and brackets with the bolts. Tighten the bolts to the recommended torque and lockwire.

NOTE: Make certain the tube assemblies are installed in their proper locations as noted at disassembly.

WATER INJECTION SYSTEM - MAINTENANCE PRACTICES

(2) Install the right and left manifold assemblies by securing them to the tube assemblies. Tighten the tube assembly nuts to the recommended torque and lockwire.

(3) Position the clamps in the locations noted at disassembly and secure them to the brackets with the nuts. Tighten the nuts to the recommended torque and lockwire.

(4) Place the water injection check valve and attached connector in position; then secure the nuts of the right and left manifold to the connector. Tighten the nuts to the recommended torque.

(5) Insert a new seal and retainer in the control end of the control-to-valve supply tube; then position the tube between the connection on the check valve and the connector on the water injection control. Tighten the nuts to the recommended torque and lockwire.

(6) Connect the upper water injection signal tube to the connector on the water injection control and the lower tube to the tee-elbow on the fuel control. Connect the upper tube to the lower tube. Tighten the nuts to the recommended torque and lockwire.

(7) Install the clip assemblies to the signal tube at the locations noted at disassembly.

2. Preservation of the Water Injection System

A. Procedure

(1) Attach a source of heated dehydrated air to the water inlet pad. Actuate the water shut-off valve to the open position.

(2) Allow the heated air at a temperature not to exceed 250°F (121°C) to blow through the system for a minimum of ten minutes.

(3) On the completion of the procedure, return the shut-off valve to the closed position.

WATER INJECTION CONTROL - DESCRIPTION AND OPERATION

General

The water injection control consists of a housing and a cap. The housing encloses the sleeve valve and its liner, and the cap encloses the spring and its adjusting screw parts. The control is designed to meter a constant water flow to the water injection manifold. This is accomplished by means of a pressure differential exerted on a spring-loaded diaphragm which in turn actuates a perforated sleeve valve that regulates the amount of water flow to the manifold.

WATER INJECTION CONTROL - MAINTENANCE PRACTICES

1. Removal/Installation of the Water Injection Control

A. Removal

(1) Disconnect the signal, water supply, control-to-check valve and drain valve tubes from the water injection control.

(2) Remove the bolts securing the control to the support assembly and remove the control.

B. Installation

(1) Secure the control to the support assembly with the four bolts and washers. Tighten and lockwire the bolts.

(2) Connect the signal tube and control-to-check valve tube to the water injection control. Tighten and lockwire the nuts.

(3) Connect the airframe water supply and drain valve tubes.

WATER PRESSURE SENSING DRAIN VALVES - DESCRIPTION AND OPERATION

Description

The water pressure sensing drain valve is composed of a valve body, a spring, a valve or cone, a retainer or cap and "O" ring seals. The valve or cone is spring-loaded to the open position.

Operation

There are two water pressure sensing drain valves in the engine water injection system. One is mounted on the fuel control and the other is attached to the water injection control. These valves are normally open under spring pressure. When water injection is turned on, the water pressure overcomes the spring pressure and closes the valve. When the water is turned off, the valve opens to permit drainage of the fluid from the system. All surplus water remaining in the system after take-off must be drained to prevent damage to the system components due to freezing.

WATER PRESSURE SENSING DRAIN VALVES - MAINTENANCE PRACTICES

1. Removal/Installation of the Water Pressure Sensing Drain Valves

A. Removal

(1) Disconnect the airframe drain tube from the valve mounted at the water injection control. Loosen and remove the drain valve from the elbow on the control.

(2) Disconnect the airframe drain tube from the valve mounted on the connector at the fuel control. Loosen and remove the drain valve from the connector.

B. Installation

(1) With the arrow pointing down, install the drain valve and a new seal on the elbow at the water injection control. Tighten the valve and lockwire. Connect the airframe drain tube to the valve.

(2) With the arrow pointing away from the connector, install the valve and a new seal on the connector at the fuel control. Tighten the valve and lockwire. Connect the airframe drain tube to the valve.

WATER INJECTION CHECK VALVE - DESCRIPTION AND OPERATION

Description

The water injection check valve is composed of a body, a valve, a spring, and appropriate gasket, seals, and connectors.

Operation

The water injection check valve is installed in the water supply line between the water injection control and the water injection manifold. The valve is spring-loaded to the closed position, and is open only during periods of water injection system operation. The purpose of this valve is to prevent high temperature compressor discharge air from backing up into the water injection system tubing and damaging the controls or valves.

WATER INJECTION CHECK VALVE - MAINTENANCE PRACTICES

1. Removal/Installation of the Water Injection Check Valve

A. Removal

(1) Loosen the two nuts securing the check valve connector to the manifold halves.

(2) Disconnect the control-to-check valve tube from the check valve by loosening the nut.

(3) Remove the check valve and connector as an assembly.

B. Installation

(1) Position the check valve and connector assembly on the manifold halves and tighten and lockwire the nuts.

(2) Tighten and lockwire the nut on the control-to-check valve tube to the check valve body.

WATER INJECTION CONTROL STRAINER HOUSING - DESCRIPTION

General

The water injection inlet connector consists of a housing, and an inlet screen and appropriate seals. This connector serves as a connecting point for the aircraft water supply line to the water injection control.

WATER INJECTION CONTROL STRAINER HOUSING - MAINTENANCE PRACTICES

1. Removal/Installation of the Strainer Housing

A. Removal

(1) Remove the four bolts, washers, and locknuts which secure the housing to the water injection control.

(2) Remove the strainer housing.

B. Installation

(1) Place a new gasket on the water injection control inlet pad; then place the housing on pad aligning the bolt holes.

(2) Secure the housing to the control with the bolts, washers, and locknuts.

2. Disassembly/Assembly of the Strainer Housing

A. Disassembly

(1) Remove the lockring and pull the strainer from the housing.

B. Assembly.

(1) Insert the strainer into the housing and secure it with the lockring.